



DEPARTMENT OF THE ARMY
US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
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19 December 2008

MEMORANDUM FOR Mr. Joseph Angello, Director, Readiness Programming and Assessment and Executive Secretary, Defense Safety Oversight Council, Office of the Under Secretary of Defense for Personnel and Readiness, 4000 Defense Pentagon, Washington, DC 20301-4000

SUBJECT: Injury Prevention Report No.12-HF-04MT-08, Preventing U.S. Military Injuries: The Process, Priorities, and Epidemiologic Evidence—A Report for the Defense Safety Oversight Council

1. We are enclosing a copy of the subject report with an Executive Summary.
2. Please contact us if you need additional information or have questions about this report.
3. The point of contact at the U.S. Army Center for Health Promotion and Preventive Medicine is Dr. Michelle Canham Chervak, Injury Prevention Program, commercial (410) 436-1377 or DSN 584-1377. Dr. Chervak may also be reached by electronic mail at michelle.chervak@us.army.mil.

FOR THE COMMANDER:

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U.S. Army Center for Health Promotion and Preventive Medicine

INJURY PREVENTION
REPORT NO. 12-HF-04MT-08

PREVENTING INJURIES IN THE U.S. MILITARY: THE PROCESS,
PRIORITIES, AND EPIDEMIOLOGIC EVIDENCE

A REPORT FOR THE DEFENSE SAFETY OVERSIGHT COUNCIL
DECEMBER 2008

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EXECUTIVE SUMMARY
INJURY PREVENTION
REPORT NO. 12-HF-04MT-08
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EPIDEMIOLOGIC EVIDENCE

A REPORT FOR THE DEFENSE SAFETY OVERSIGHT COUNCIL
DECEMBER 2008

1. A SYSTEMATIC EVIDENCE-BASED PROCESS FOR SETTING PRIORITIES AND
PREVENTING INJURIES: RECOMMENDATIONS FOR THE MILITARY.

A. INTRODUCTION. Injuries are the biggest health problem confronting U.S. military forces in peacetime and combat operations, resulting in over 1.8 million medical encounters annually across the Services and affecting more than 800,000 individual Service members. Not only are injuries the biggest health problem of the Services, but they are also a complex problem. The leading causes of deaths are different from those that result in hospitalization, which are different from those that result in outpatient care. As a consequence, it is not possible to focus on just one level of injury severity if the impact of injuries on military personnel is to be reduced. To effectively reduce the impact of a problem as big and complex as injuries requires a systematic approach. The purpose of this summary is to introduce the concepts behind a systematic approach to injury prevention. Specifically, the following will be presented: (1) the steps of the public health approach to injury prevention, (2) relevant literature on the evidence-based process for systematic evaluation of the scientific quality and consistency of information needed to make decisions to implement injury prevention policies, programs and interventions, and (3) criteria for setting objective injury prevention priorities. The review of these topics will serve as a foundation for making recommendations to enhance the effectiveness of injury prevention efforts in the military.

B. PURPOSE. In the chapters that follow, this report will: (1) describe a systematic, evidence-based approach to military injury prevention; (2) provide an example of how data-driven priorities can be set using military surveillance and research data; (3) illustrate how surveillance data can be used to identify and monitor injury problems for the military; (4) demonstrate how accident report data can provide details necessary for prevention planning; (5) show how systematic reviews can be employed to provide military-relevant information on what works to prevent injuries; (6) report results of military injury prevention program evaluations and intervention trials; and (7) present a method for calculating injury costs.

2. RESULTS OF A SYSTEMATIC PROCESS TO PRIORITIZE MILITARY PREVENTION ACTIVITIES.

A. BACKGROUND. To sustain progress toward injury reduction and other health promotion goals, public health organizations need a systematic approach based on data and an evaluation of existing scientific evidence on prevention. This chapter describes a process and criteria developed to identify leading causes of injury and objectively prioritize prevention efforts.

B. METHODS. Military epidemiology and injury experts used predefined criteria to score ten military-relevant unintentional injury issues. Criteria assessed the importance of the problem based on available epidemiologic data, effectiveness of existing prevention strategies, feasibility of establishing programs and policies, timeliness, and potential for evaluation of effects. Injury problems were ranked by total mean score and the Multiple Attribute Decision Making (MADM) method.

C. RESULTS. Categories with the highest total mean scores were physical training (32.2 points), privately owned vehicle accidents (29.8 points), military parachuting (29.4 points), sports (29.0 points), and military vehicle accidents (28.1 points). The MADM method resulted in the following scores: physical training (85.1), military parachuting (79.7), privately owned vehicle accidents (77.7), sports (72.3), falls (67.4), and military vehicle accidents (67.4).

D. CONCLUSIONS. The process identified three injury issues (physical training-related injuries, privately owned vehicle accidents, and military parachuting injuries) with greatest potential for successful program and policy implementation. Such information is useful for public health practitioners and policymakers who must prioritize among health problems that are competing for limited resources. The process and criteria could be adapted to systematically assess and prioritize health issues in smaller subsets of the military population, such as bases or installations.

3. **MILITARY INJURY SURVEILLANCE: OVERVIEW AND SELECTED INJURY ISSUES**. This chapter contains six sections, covering the following surveillance topics: (1) summary medical surveillance data on all military injuries, (2) musculoskeletal/overuse injuries, (3) noise-induced hearing injuries, (4) eye injuries, (5) oral-maxillofacial injuries, and (6) nonbattle injuries during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). These sections are described in greater detail below.

A. MEDICAL SURVEILLANCE OF INJURIES IN THE MILITARY: UTILITY, COMPARABILITY, AND RECOMMENDATIONS.

(1) **BACKGROUND**. Injury surveillance is the first and most critical step of the injury prevention process. Without it, successful injury prevention could not be sustained. The

purpose of this section is to describe advances in military medical surveillance, define the size and causes of the injury problem for the military, and make recommendations for improved surveillance and injury prevention.

(2) METHODS. Medical and personnel data were obtained from the Armed Forces Health Surveillance Center for 2000–2006. Rates of nonfatal injuries and injury-related musculoskeletal conditions, frequencies of injury types, and causes of injury hospitalizations are described. Cause data were not available for outpatient injuries.

(3) RESULTS. Injuries were the leading cause of medical encounters among military personnel. The rate of hospitalization for injuries was approximately 1,000 per 100,000 person-years, and the rate of injuries treated in outpatient clinics was 999 per 1,000 person-years. The leading injury type resulting in hospitalization was fractures (40 percent) and the leading injury type resulting in outpatient visits was sprains and strains (49 percent). Leading causes of hospitalization were falls/near falls (17.5 percent), motor vehicle mishaps (15.4 percent), and sports (13.1 percent).

(4) CONCLUSIONS. Injuries are the biggest health problem of the Services, and rates are not much different than for those for U.S. populations. Military medical surveillance data are useful for demonstrating the magnitude of the injury problem, possible prevention targets, and monitoring of trends among military personnel but could be improved especially with cause coding of outpatient data.

B. MUSCULOSKELETAL/OVERUSE INJURIES: DESCRIPTION OF AN UNDER-RECOGNIZED INJURY PROBLEM AMONG MILITARY PERSONNEL.

(1) BACKGROUND. Though injuries are recognized as a leading health problem in the military, the size of the problem is under estimated when only acute traumatic injuries are considered. Injury-related musculoskeletal conditions are common in this young, active population. Many of these involve physical damage caused by microtrauma (overuse) in recreation, sports, training, and job performance. The purpose of this section is to define the incidence of injury-related musculoskeletal conditions in the military (2006) and describe a standardized format (matrix) to categorize and report them.

(2) METHODS. The subset of musculoskeletal conditions found to be injury-related in previous military investigations was identified. Occurrences of these conditions among nondeployed Active Duty military personnel in 2006 were identified from military medical surveillance data. A matrix was used to report and categorize these conditions by injury type and body region.

(3) RESULTS. There were 743,547 injury-related musculoskeletal conditions treated in 2006 (outpatient and inpatient, combined), including primary and non-primary diagnoses. In the matrix, 82 percent of injury-related musculoskeletal conditions were classified as inflammation/pain (overuse), followed by joint derangements (15 percent) and stress fractures (2 percent). The knee/lower leg (22 percent), lumbar spine (20 percent), and ankle/foot (13 percent) were leading body region categories.

(4) CONCLUSIONS. When assessing the magnitude of the injury problem in the Services, injury-related musculoskeletal conditions should be included in the definition of injury. When these conditions are combined with traumatic injuries, there are over 2 million injury-related encounters each year. The matrix provides a standardized format to categorize these injuries, compare over time, and focus prevention efforts on leading injury types and/or body locations.

C. NOISE-INDUCED HEARING INJURY SURVEILLANCE IN THE MILITARY, 2003–2005.

(1) BACKGROUND. The rates of noise-induced hearing injury (NIHI) among Active Duty military personnel have not been previously described. This section reports frequencies, distributions, and rates of NIHI among Active Duty military personnel, 2003–2005.

(2) METHODS. Noise-induced hearing injuries were identified in the Defense Medical Surveillance System (DMSS) using a list of International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes selected in collaboration with military audiologists. To provide a more comprehensive view of the NIHI problem, NIHI-related ICD-9 codes beyond the traditional 388 noise injury code set were included.

(3) RESULTS. Overall, NIHI rates among Active Duty military personnel increased from 2003 to 2005. During this time period, female rates ranged from 11.7 to 24.6 per 1,000 person-years; male rates ranged from 18.1 to 26.8 per 1,000 person-years. Noise-induced hearing injury rates were highest among those over age 40 (mean rate=53.7 per 1,000 person-years) and lowest among those 17-19 years of age (mean rate=12.5 per 1,000 person-years). Among occupational groups, general officers and executives had the highest NIHI rate over this time period (29.5 per 1,000 person-years), followed by enlisted personnel in training (14.3 per 1,000 person-years) and scientists and professionals (12.8 per 1,000 person-years).

(4) CONCLUSIONS. Medical surveillance systems, such as DMSS, provide essential information for tracking NIHI and monitoring NIHI intervention effects. However, data on outpatient injury causes and use of hearing protection is also needed to guide the future design and/or modification of interventions.

D. EYE INJURY SURVEILLANCE IN THE MILITARY, 1996–2005.

(1) BACKGROUND. The U.S. military eye injury rates have not been fully described. Previous studies looked at inpatient, outpatient, and safety data, but none have looked at combined outpatient and inpatient data over time to produce a comprehensive description of eye injuries among Active Duty military personnel. This section reports rates of eye injuries (inpatient and outpatient visits) among Active Duty military personnel for 1996–2005, presents known causes, and recommends approaches to improving eye injury surveillance.

(2) METHODS. Medical visit data on Active Duty military personnel, 1996–2005, and causes of eye injury hospitalizations were obtained from the DMSS. Eye injury-related ICD-9 codes beyond the traditional 800–999 injury code set were included.

(3) RESULTS. Eye injury rates among Active Duty military personnel increased from 1996 to 2005, with the highest rates seen in 2004 (26/1000 person-years and 21/1000 person-years, females and males, respectively). Leading causes of eye injury hospitalizations were falls and miscellaneous (38 percent), guns/explosives (20 percent), and enemy action (16 percent).

(4) CONCLUSIONS. Eye injury rates have risen over the period 1998–2005, due in large part to improvements made in coding and data capture, and also the impact of 3 years of warfare on the Active Duty population. Medical surveillance data enable the assessment and monitoring of overall eye injury rates, trends, and causes; however, these data lack information on causes of outpatient injury and use of eye protection at the time of injury—information that is needed to inform decisions on the design or modification of intervention strategies.

E. ORAL-MAXILLOFACIAL INJURY SURVEILLANCE IN THE MILITARY, 1996–2005.

(1) BACKGROUND. Oral-maxillofacial injuries can lead to deformity and malfunction, greatly diminishing quality of life and worker productivity. Data suggest that over 10 percent of civilian emergency room visits are due to craniofacial injuries. The size and scope of oral-maxillofacial injuries in the military is not well understood. This section reports Active Duty military personnel rates of oral-maxillofacial injuries; causes of oral-maxillofacial hospitalizations; and recommended approaches to improving surveillance, research, and prevention.

(2) METHODS. Active Duty military personnel, who sought inpatient or outpatient treatment for one or more oral-maxillofacial injuries from 1996–2005, were identified in the DMSS using ICD-9-CM diagnosis codes associated with oral-maxillofacial injuries. The ICD-9-CM diagnosis codes were divided into two categories: oral-maxillofacial wounds and oral-maxillofacial fractures. Multiple visits for the same diagnosis within 60 days of the initial visit were excluded to reduce the effect of follow-up visits.

(3) RESULTS. The oral-maxillofacial fracture rates for men were consistently 1.5 to 2 times higher than those for women (mean rate, 2000-2005=1.4 and 0.9 per 1,000 person-years, men and women, respectively). Wound rates for men and women were similar over time (mean rate, 2000-2005=13.2 and 13.9 per 1,000 person-years, men and women, respectively). Active Duty military personnel, under age 25, had the highest rates of both oral-maxillofacial fractures (mean rates, 2000-2005:17-19 years=1.8 per 1,000 person-years, 20-24 years=1.9 per 1,000 person-years) and wounds (mean rates, 2000-2005:17-19 years=21.0 per 1,000 person-years, 20-24 years=18.7 per 1,000 person-years). Fighting (13.5 percent) was the leading cause of oral-maxillofacial injury hospitalizations in 2005.

(4) CONCLUSIONS. Military and civilian populations would benefit from a surveillance system that incorporates not only medical care data but also dental care data. There is also a need for additional quality intervention studies on the strategies to prevent oral and craniofacial injury.

F. NONBATTLE INJURIES AIR-EVACUATED FROM OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM (U.S. ARMY), 2001–2006.

(1) BACKGROUND. Medical information systems during past military deployments had limited injury surveillance capability since data were not accessible during the deployments and causes of injury were not captured. This section describes the nonbattle injury (NBI) results of an on-going surveillance program that identifies injury occurrences and causes during current Army deployments supporting OIF and OEF.

(2) METHODS. Soldiers medically evacuated from U.S. Central Command (CENTCOM), while deployed for OIF (March 2003–2006) and OEF (October 2001–2006), were identified from air-evacuation records. Trained coders reviewed each air-evacuation case to determine casualty type (NBI, battle injury, or illness), diagnosis, and affected body region, as well as to identify cause of injury from free-text patient histories. Descriptive statistics were used to describe and compare evacuees from OIF and OEF.

(3) RESULTS. Air evacuations of Soldiers from CENTCOM totaled 27,563 from OIF and 4,165 from OEF. Nonbattle injuries accounted for 35 percent and 37 percent of OIF and OEF evacuation cases, respectively, and was the largest single general category for each operation. The leading air-evacuated NBI for both OIF and OEF was fractures (35.3 percent and 34.4 percent, OIF and OEF, respectively). Distributions for NBI diagnosis ($p=0.32$) and injured body region (0.51) were similar for both operations. Leading causes of NBI were the same for both operations: sports/physical training (19–21 percent), falls/jumps (18 percent), motor vehicle-related accidents (12–16 percent), and crushing/blunt trauma (9 percent).

(4) CONCLUSIONS. Routinely collected air-evacuation data provided the basis for ongoing injury surveillance during OIF and OEF. Nonbattle injury was the largest diagnosis category of medical evacuations from both operations. Leading NBI causes were similar to those for past conflicts, and many should be preventable.

4. USE OF ACCIDENT REPORTS TO IDENTIFY OPPORTUNITIES FOR PREVENTION: EXAMPLES FROM THE U.S. AIR FORCE SAFETY CENTER. This chapter contains five sections. The first section (4–1) describes methods for using accident report data to describe injury-producing scenarios. The remaining four sections present results from analyses of accident report data on the following injury topics: (1) objects associated with lifting, handling, and carrying injuries, (2) mechanisms of injury during slow pitch softball, (3) mechanisms of injury during basketball, and (4) mechanisms of injury during flag football. These sections are described in greater detail below.

A. USING SAFETY DATA TO DESCRIBE COMMON INJURY-PRODUCING SCENARIOS: AN EXAMPLE FROM THE U.S. AIR FORCE.

(1) BACKGROUND. The U.S. military leadership has recently increased its efforts to reduce the number of lost workday injuries for both the Active Duty and civilian personnel components of the Total Force. Most of those injuries occur in the official mishap Class C category that generally consists of nonfatal and nondisabling injuries. The causes and circumstances of those injuries—information needed for injury prevention—has largely been unexplored.

(2) METHODS. Using narrative text and coded data available in the U.S. Air Force (USAF) Ground Safety Automated System, hazard scenarios were constructed for injury-producing mishaps that occurred from 1993–2002 (N = 32,812 injuries). Several essential data elements, necessary for reconstruction of event causes and circumstances, were identified in both coded data and in free-text mishap narratives. Activities and mechanisms were coded in a format similar to that of the ICD-10. A taxonomy to identify hazard scenarios specific to the injury-producing activity or mechanism was subsequently developed.

(3) RESULTS. Coded data provided four data elements (activity, injury event/exposure, nature of injury/body part, and outcome) that were sufficiently descriptive or complete for full use. The remainder of the information was coded from narratives. The assembled data enabled identification and description of the most common injury-producing mechanisms and activities, which are presented in this section. Hazard scenarios were also identified for the major activities and mechanisms, and these are described in the following sections.

(4) CONCLUSIONS. The USAF safety reporting makes in-depth analysis and description of lost workday injuries possible. However, most of the required data may be found in the free-text narrative report.

B. LIFTING, HANDLING, AND CARRYING: OBJECTS ASSOCIATED WITH INJURY IN ACCIDENT REPORTS.

(1) BACKGROUND. The USAF Active Duty and civilian personnel experience a significant number of lost workday injuries while lifting, handling, and carrying objects. The purpose of this section is to describe the hazard scenarios of lift-handle-carry (LHC) injuries to better identify effective countermeasures.

(2) METHODS. The data were derived from safety reports obtained from the USAF Ground Safety Automated System. Lift-handle-carry injuries for the years 1993–2002, which resulted in at least one lost work day, were included in the analysis. A total of 4,085 lost workday injuries, resulting in 24,940 lost workdays for USAF military and civilian members, met the criteria for inclusion. Objects from these reports were identified and aggregated to determine the most common causes of LHC injuries.

(3) RESULTS. Twelve distinct objects or type of objects were identified as the most common sources of LHC injury. One object—aircraft components—represented 33 percent of all military and civilian LHC injuries. The next leading objects associated with LHC injuries were boxes (10 percent) and furniture (7 percent).

(4) CONCLUSIONS. Safety report data can be used to identify the most common object or object types causing LHC injuries. This information can be used to develop evidence-based countermeasures. In the USAF, countermeasures to address LHC injuries among aircraft maintenance workers are warranted.

C. SLOW PITCH SOFTBALL: MECHANISMS OF INJURY FROM ACCIDENT REPORTS.

(1) BACKGROUND. Softball is a popular sport in civilian and military populations and causes a large number of lost workday injuries. The purpose of this section is to describe the mechanisms associated with softball injuries occurring among Active Duty USAF personnel to better identify effective countermeasures.

(2) METHODS. Data derived from safety reports were obtained from the USAF Ground Safety Automated System. Softball injuries for the years 1993–2002, which resulted in at least 1 lost work day, were included in the analysis. Narrative data were systematically reviewed and coded in order to categorize and summarize mechanisms associated with these injuries.

(3) RESULTS. Softball injuries reported in 1,171 mishap reports, resulting in 6,843 total lost work days. Eight independent mechanisms were identified. Three specific scenarios (sliding, being hit-by-ball, and collisions) represented 60 percent of softball injuries.

(4) CONCLUSIONS. Major and minor mechanisms of injury caused by playing softball, which are necessary for prevention, can be identified using the detailed information found in safety reports. Within the USAF, interventions to reduce injuries related to sliding, being hit-by-ball, and collisions should be implemented.

D. BASKETBALL: MECHANISMS OF INJURY FROM ACCIDENT REPORTS.

(1) BACKGROUND. Basketball is the most popular sport among the USAF Active Duty personnel and causes a large number of lost workday injuries. The purpose of this section is to describe how basketball injuries occur to allow development of effective countermeasures.

(2) METHODS. Data were derived from safety reports obtained from the USAF Ground Safety Automated System. Basketball injuries for the years 1993–2002, which resulted in at least one lost work day were included in the analysis. Mechanisms of basketball mishaps were defined using details in the safety reports. The 2,204 mishap reports, involving Active Duty USAF members playing basketball, were included in the analysis.

(3) RESULTS. Eight mechanisms causing injury were identified. Most importantly, two similar causes involving jumping (landing awkwardly and landing on someone's foot) represent 43 percent of basketball injuries.

(4) CONCLUSIONS. The mechanisms of injury caused by playing basketball, which are necessary for prevention, can be identified using the detailed information found in safety reports. Results suggest that basketball injuries among USAF personnel could be significantly reduced by requiring the use of semi-rigid ankle braces for on-base basketball.

E. FLAG FOOTBALL: MECHANISMS OF INJURY FROM ACCIDENT REPORTS.

(1) Flag (touch or intramural) football is a popular sport among the Active Duty personnel and causes a significant number of lost workday injuries. The purpose of this section is to describe the mechanisms of flag football injuries to better identify effective countermeasures.

(2) METHODS. The data was derived from safety reports obtained from the USAF Ground Safety Automated System. Flag football injuries for the years 1993–2002, which resulted in at least 1 lost workday were included in the analysis. The 944 mishap reports involving Active Duty USAF personnel playing flag football met the criteria for inclusion.

(3) RESULTS. Eight mechanisms of injury were identified. Most importantly, one scenario (contact with another player) represented 42 percent of all flag football injuries.

(4) CONCLUSIONS. The most common mechanisms of injury caused by playing flag football can be identified using the detailed information found in safety reports. These scenarios are essential to developing evidence-based countermeasures. Results suggest that the USAF could significantly reduce flag football-related injuries by implementing and enforcing rules to minimize contact (such as, no tackling).

5. REVIEWS OF THE SCIENTIFIC EVIDENCE TO IDENTIFY OPPORTUNITIES FOR PREVENTION. This chapter contains four sections, two of which describe systematic literature reviews to identify existing interventions for two leading causes of military injuries, physical training-related injuries and military motor vehicle injuries. Two additional sections describe scientific evaluations of specific prevention strategies, one of which addresses parachuting-related injuries (parachute ankle brace) and another that addresses physical training-related injuries (running shoe assignment based on plantar surface shape). These sections are described in greater detail below.

A. RECOMMENDATIONS FOR PREVENTION OF PHYSICAL TRAINING-RELATED INJURIES: RESULTS OF A SYSTEMATIC, EVIDENCE-BASED REVIEW.

(1) BACKGROUND. The Military Training Task Force (MTTF) of the Defense Safety Oversight Council chartered a Joint Services Physical Training Injury Prevention Work Group (JSPTIPWG) to: (1) establish the evidence base for making recommendations to prevent injuries, (2) prioritize the recommendations for prevention programs and policies, and (3) substantiate the need for further research and evaluation on interventions and programs likely to reduce physical training-related injuries.

(2) METHODS. Twenty-nine military and civilian scientists, public health practitioners, clinicians, and training officers served on the JSPTIPWG. Prior expert panel results and additional brainstorming were used to generate a list of prevention strategies with potential to reduce the incidence of PT-related injuries. Systematic reviews of the literature and quality assessments of intervention and risk factor studies were conducted. Interventions were then categorized into three levels representing the strength of recommendation: (1) recommended, (2) not recommended, and (3) insufficient evidence to recommend or not recommend.

(3) RESULTS. Systematic reviews were conducted for 34 of the identified potential prevention strategies. Of these, three were determined to be essential elements of a successful injury prevention program and not interventions in and of themselves. One more essential element was added for a total of four: (1) education, (2) leadership, (3) surveillance,

(4) research and program evaluation. Six interventions had strong enough evidence to become JSPTIPWG recommendations for implementation in all four Services immediately: (1) prevent overtraining, (2) perform multiaxial, neuromuscular, proprioceptive, and agility training, (3) wear mouth guards during high risk activities, (4) wear semi-rigid ankle braces for high risk activities, (5) consume nutrients to restore energy balance within 1 hour following high intensity activity, and (6) wear synthetic blend socks to prevent blisters. Two interventions were not recommended due to evidence of ineffectiveness or harm: (1) use of back braces, harnesses or support belts, and (2) anti-inflammatory medication prior to exercise. The 23 prevention strategies lacked sufficient scientific evidence to support recommendations at this time, and six were not evaluated. Stretching was an intervention with insufficient evidence.

(4) CONCLUSIONS. Six interventions should be implemented in all four Services immediately. Two strategies should be discouraged by leaders at all levels. Injury researchers interested in studying the prevention of physical training-related injuries in the military should begin with our list of strategies with the insufficient evidence to recommend. The systematic process of evaluating interventions enabled the JSPTIPWG to build Quad-Service consensus around those injury prevention strategies that had enough scientific evidence to support a recommendation. Preventing physical training-related injuries will have a significant effect on military operational readiness by decreasing entry-level attrition and separation due to injury.

B. PARACHUTE ANKLE BRACE: INJURY REDUCTION CAPABILITY, BREAKAGE, SERVICE MEMBER ATTITUDES, AND MODIFICATIONS TO IMPROVE BRACE EFFECTIVENESS.

(1) BACKGROUND. Previous studies of the parachute ankle brace (PAB) showed that PAB use reduced injuries in airborne training. However, PAB use had been discontinued due to concerns about increased incidence of other injuries and entanglements. This evaluation was undertaken to address these concerns.

(2) METHODS. While PABs were being phased into U.S. Army Airborne School training, data on injuries, entanglements, jump-related factors, and Service member demographics were collected.

(3) RESULTS. A total of 596 injuries occurred during 102,784 jumps, for an overall cumulative injury incidence of 58 injuries/10,000 jumps. In a multivariate analysis controlling for wind speed, night operations, and combat loads, students not wearing the brace were 1.90 (95 percent confidence interval (CI)=1.24–2.90) times more likely to experience an ankle sprain, 1.47 (95 percent CI=0.82–2.63) times more likely to experience an ankle fracture, and 1.75 (95 percent CI=1.25–2.48) times more likely to experience an ankle injury of any type when compared with students who wore the brace. The risk ratio (RR) (RR, no brace/brace) for lower body injuries exclusive of the ankle was RR=0.92 (95 percent CI=0.65–1.30), for lower body fractures exclusive of the ankle RR=0.99 (95 percent CI=0.59–1.67), and for lower body strains and sprains exclusive of the ankle RR=1.45 (95 percent CI=0.73–2.87). Entanglement incidence

in the brace and nonbrace groups were 9.6/10,000 jumps and 7.5/10,000 jumps, respectively (p=0.33).

(4) CONCLUSIONS. The PAB protected against ankle injuries, especially ankle sprains, during military parachute training. Injuries to other parts of the lower body, exclusive of the ankle, were not different among those who wore the brace and those who did not. Entanglement incidence was also similar among brace wearers and nonwearers, indicating that the PAB did not complicate entanglements.

C. INJURIES DUE TO MILITARY MOTOR VEHICLE CRASHES.

(1) BACKGROUND. The purpose of this section was to conduct a systematic review of published evidence on injuries due to military motor vehicles and to promote further epidemiologic research to inform future injury prevention efforts.

(2) METHODS. We searched 18 electronic databases for studies on injuries related to military motor vehicles. We narrowed our literature review to include English language publications addressing military motor vehicle (MMV) crash-related injuries between 1970 and 2006 that were available to the general public. Limited distribution documents were not evaluated. We then categorized the relevant articles by study design.

(3) RESULTS. Our search strategy identified only 13 studies specifically related to crashes of MMVs. Most of these studies were case reports/case series (n = 8); only one could be classified as an intervention study. Nine of the studies were based solely on data from Service-specific military safety centers.

(4) CONCLUSION. Few published studies, available in the scientific literature, exist on injuries related to crashes of MMVs. Epidemiologic studies that assess injury type, severity, and risk factors are needed, followed by studies to evaluate targeted interventions and prevention strategies. Interventions currently underway should be evaluated for efficacy, and interventions proven effective in the civilian community, such as graduated driver licensing, should be considered for implementation and evaluation in military populations.

D. AN EVALUATION OF FOOTWEAR, FITNESS, AND INJURIES.

(1) BACKGROUND. In response to a request from the Military Training Task Force of the Defense Safety Oversight Council, this study examined whether assigning running shoes based on the shape of the plantar surface influenced injury risk in Air Force Basic Military Training (BMT).

(2) **METHODS.** Data were collected from BMT recruits during 2007; analysis took place during 2008. After foot examinations, recruits in an experimental group (E, n=1,042 men, 375 women) were assigned motion control, stability, or cushioned shoes for plantar shapes indicative of low, medium, or high arches, respectively. A control group (C, n=913 men, 346 women) received a stability shoe regardless of plantar shape. Injuries during BMT were determined from outpatient visits provided by the Army Medical Surveillance Activity (now the Armed Forces Health Surveillance Center). Other known injury risk factors (such as, fitness, smoking, and physical activity) were obtained from a questionnaire, existing databases, or BMT units.

(3) **RESULTS.** Multivariate Cox regression controlling for other risk factors showed little difference in injury risk between the E and C groups among men (hazard ratio (E/C)=1.11, 95 percent confidence interval=0.89–1.38) or women (hazard ratio (E/C)=1.20, 95 percent CI=0.90–1.60).

(4) **CONCLUSION.** This prospective study demonstrated that assigning running shoes based on the shape of the plantar surface had little influence on injury risk in BMT even after controlling for other injury risk factors.

6. ESTIMATING INJURY COSTS: THE ARMY MEDICAL COST AVOIDANCE MODEL. A medical cost avoidance model (MCAM) to estimate the costs associated with the failure to abate or control health hazards in Army materiel systems was developed by the Logistics Management Institute in 1997. An updated version of the model (2003) is presented, which uses cost factors for individual health hazard categories. The earlier model calculated medical costs associated with Army materiel based on a single-cost factor for all hazard categories. The Army's Health Hazard Assessment (HHA) Program, which currently uses the MCAM during the process of assessing 18 health hazard categories found in materiel acquisition, recognized the need to further refine the cost model to be hazard specific. These hazard specific categories have unique cost factors and serve as the basis for the revised model. The revision will greatly increase the model's precision and validity while assisting the HHA Program in targeting health hazards having the potential of affect Soldier health and readiness.

7. CONCLUSIONS.

A. Adoption of a data-driven, evidence-based approach to prevention, as described in Chapters 1 and 2, offers the Services and Department of Defense an opportunity to not only significantly reduce the incidence of injuries to Service members but also to establish a model for safety and public health practice for military and civilian communities.

B. Medical surveillance data show that injuries are the largest medical problem for the Services. In 2006, acute and chronic injuries accounted for 1.8 million outpatient encounters and 12,000 hospitalizations. For every one injury death, there are approximately 16 hospitalizations

and 1,500 outpatient visits. Injury-related musculoskeletal conditions account for over 50 percent of all injury-related outpatient encounters and 30 percent of all injury hospitalizations (2006 data). Auditory, visual, and oral-maxillofacial injuries are important, often overlooked military injury issues. Nonbattle injuries are the leading cause of air medical evacuations from OIF and OEF, accounting for 35 percent of all air medical evacuations from 2003–2006.

C. Safety data provide detailed cause information needed for prevention planning. Detailed analyses of safety data were conducted on the following: injuries due to lifting, handling, and carrying (LHC), softball, basketball, and flag football.

(1) LHC injuries were concentrated in the civilian Air Force population, age 35–55. The majority of injuries affected the back, and a large proportion were associated with work on aircraft components. Countermeasures to prevent LHC injuries in aircraft maintenance workers are warranted.

(2) Results indicated that softball injuries were predominantly caused by sliding, being hit by a ball, and collision. Potential prevention measures include use of breakaway bases, banning sliding, restricting headfirst sliding, use of two home plates, use of a helmet and face guard at all times, use of reduced injury factor balls, and training-to-call balls.

(3) Two specific mechanisms—landing awkwardly and landing on someone else’s foot—represent 43 percent of basketball injuries. The large number of ankle sprains presents a unique opportunity for prevention through the introduction of ankle braces.

(4) Forty-two percent of injuries during flag football are due to contact. Potential countermeasures include rule changes and increased enforcement of rules.

D. Systematic reviews are an accepted method for identifying effective ‘proven’ interventions and evaluating the quality of existing interventions. When prevention strategies are implemented, program evaluation is needed to evaluate success. When prevention strategies do not exist, intervention trials are needed to determine effectiveness and assess costs/savings.

(1) A systematic review of 34 interventions to prevent physical-training related injuries revealed only 17 percent (n=6) with strong enough scientific evidence to be recommended: prevention of overtraining, performance of multiaxial agility training, use of mouth guards during high-risk activities, use of semi-rigid ankle braces during high-risk activities, consumption of nutrients to restore energy balance within 1 hour following high intensity exercise, and use of synthetic blend socks to prevent blisters. Two interventions (use of back braces, harnesses, or support belts, and use of anti-inflammatory medication prior to exercise) were not recommended due to evidence of ineffectiveness or harm. Also, stretching had insufficient evidence to recommend.

(2) A systematic review of the scientific literature on military motor vehicle (MMV) crashes revealed few studies on the topic. Given the overlap between operation of MMVs and privately owned vehicles (POVs), evaluation of interventions that have proven effective in POVs (such as side airbags, electronic stability control, graduated driver licensing, primary seat belt laws, speed limit enforcement) is reasonable to consider.

(3) Evaluation of a parachute ankle brace (PAB) program demonstrated that the PAB protected against ankle injuries, especially ankle sprains, during military parachute training. Injuries to other parts of the lower body, exclusive of the ankle, were not different among those who wore the brace and those who did not. Entanglement incidence was also similar among brace wearers and nonwearers, showing that the PAB did not complicate entanglements. Thus, evidence for brace use was strong and potential harms were negligible or absent.

(4) An intervention trial conducted in Army and Air Force basic training demonstrated that prescribing running shoes based on plantar shape did not reduce injury rates. The study also showed there was little difference in injury rates among those who wore a standard stability shoe and those who wore a shoe designed by running shoe companies for a specific plantar shape.

8. RECOMMENDATIONS.

- A. Need for a systematic approach to the prevention of military injuries.
- B. Begin with analysis of existing surveillance data. Identify the most common and/or serious injury types and/or causes on an annual or biannual basis.
- C. Next, identify 'proven', off-the-shelf strategies (strategies demonstrated to be effective) for the most common and/or serious injury types and/or causes.
- D. Set priorities for policy and program implementation on the basis of the magnitude of the problem (according to surveillance data) and preventability (as determined by reviews of proven prevention strategies).
- E. Implement programs and policies for top priorities.
- F. Evaluate implemented programs and policies to ensure effectiveness (injury reductions are obtained, benefits outweigh costs). Some interventions will work as expected (such as, the parachute ankle brace and standardized physical training), and some will not (such as, choosing running shoes according to foot type and stretching prior to physical training).

G. Initiate research where an understanding of risk factors and/or evaluation of prevention strategies is lacking and the problem is large (such as, falls, sports) or unique to the military (such as, military vehicle accidents).

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CHAPTER 1

A SYSTEMATIC EVIDENCE-BASED PROCESS FOR SETTING PRIORITIES AND PREVENTING INJURIES:
RECOMMENDATIONS FOR THE MILITARY

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1-1. INTRODUCTION.

A. INJURIES IN THE MILITARY: A LARGE PROBLEM.

(1) Injuries are the biggest health problem confronting U.S. military forces in peacetime and combat operations. Of all the health problems encountered by military personnel, injuries pose the biggest threat to the health and readiness of military Service members.^(1, 2) Injuries result in over 1.8 million medical encounters annually across the Services and affect more than 800,000 individual Service members.⁽³⁾ The second leading cause of medical encounters—mental disorders—results in about 750,000 encounters annually affecting about 190,000 Service members. Historically, injuries have been shown to be the leading cause of deaths, disabilities, hospitalizations, and outpatient visits.⁽³⁻⁷⁾ While battle injuries are the leading cause of death in Operations Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), non-battle injuries are the leading cause of health conditions serious enough to require air-medical evacuations out of the theater of operations. Non-battle injuries account for about 35 percent of such medical evacuations compared to 16 percent for battle injuries and 7 percent for digestive diseases, the leading noninjury reason for medical evacuation (unpublished data). The evidence clearly shows that, relative to other health problems, injuries have the biggest impact on the health and combat readiness of military personnel.

(2) In the past, military surveillance of injuries and accidents has focused primarily on fatalities, especially motor vehicle and aviation fatalities. Since the late 1990s, however, increasing attention has been directed towards nonfatal injuries following establishment of the Defense Medical Surveillance System in 1997.⁽⁸⁾ As a result of the recent focus on nonfatal injuries, it has been shown that for every noncombat injury death of a military Service member, there are 33 hospitalizations for injuries and 3,800 outpatient clinic visits for injuries.⁽⁹⁾ It has also been estimated that injuries result in about 25,000,000 days of limited duty among Service members annually.⁽⁹⁾ Thus, it is clear that injuries are a tremendous drain on military manpower during peacetime and times of armed conflict.

B. INJURIES IN THE MILITARY: A COMPLEX PROBLEM.

(1) In addition to being a huge problem, injuries are also a complex problem for the military. Among other complexities, as with civilian communities, the leading causes of injury vary widely depending on the level of severity of injuries. For instance, historically, motor vehicle crashes have been the leading cause of unintentional, non-battle injury deaths across all the Services accounting for 55 to 64 percent of all unintentional injury deaths,⁽¹⁰⁾ resulting in 5 to 10 times as many deaths as the next leading specific injury causes (such as, drowning, fires/burns, or falls, depending on the Service).⁽⁵⁾ On the other hand, the top three causes of injury hospitalization of military personnel have been documented to be falls, athletics (sports), and motor vehicle crashes.⁽⁶⁾ In 2006, the leading cause of injury hospitalizations for military personnel was falls and near falls (slips and trips), which accounted for 17.5 percent of such

hospitalizations, followed by motor vehicle mishaps at 15.4 percent, and then sports and athletics at 13.1 percent (unpublished data). The same three causes of injuries—falls, sports, and motor vehicle mishaps—are also the leading causes of air medical evacuations from operations in Iraq and Afghanistan.⁽²⁾ For injuries of less severity treated in outpatient clinics, the only data available on causes of injuries come from the Army. That data indicated that physical training is the leading cause of outpatient injury visits, accounting for 25 to 40 percent of such injuries.^{(11,}

¹²⁾ On the other hand, motor vehicle mishaps account for less than 5 percent of all injuries treated in outpatient clinics and rank no higher than seventh or eighth compared to other causes. It is clear from data such as these that, if priorities for military injury prevention were set based on fatalities, the major causes of the majority of injuries—physical training and falls—would not be addressed.

(2) Adding further to the complexity of the problem of injuries, the circumstances of injuries resulting from similar causes can be quite different. As an example, falls can occur from stairs or ladders, heights, and on the same level (for example, due to slips or trips while walking) during garrison or combat conditions.⁽¹³⁾ Likewise, athletics result in frequent, sometimes serious injuries associated with a variety of sports occurring under varied circumstances.⁽¹⁴⁾

(3) With regard to prevention, where attention has been focused and surveillance systems are in place, success has been achieved. For instance, just like the civilian community, the military has had great success preventing injuries and deaths associated with privately owned motor vehicle crashes.⁽¹⁵⁾ Furthermore, since an abundance of evidence for further prevention is available from established civilian organizations such as the National Highway Traffic Safety Administration, the Centers for Disease Control and Prevention, the Insurance Institute for Highway Safety, and academic organizations, the military can adopt civilian approaches already demonstrated to be effective. But for most injury problems, even large potentially serious injury problems such as falls, very little prevention information is available. For problems such as falls, where scientific information is scant, systematic reviews to identify proven off-the-shelf solutions need to be conducted; where gaps in knowledge exist, research needs to be conducted before policies and programs are implemented.

C. PURPOSE. As with any large community or occupational group, for a public health problem as big and complex as injuries in the military, a systematic approach to planning and setting priorities is needed for prevention activities to succeed. Because resources for prevention are scarce, a process is needed for setting priorities that identifies not only effective countermeasures but also ones that impact the health of the largest number of personnel at the lowest costs.^(16, 17) When scientific evidence is available, a process for evaluating the quality of individual studies is needed and a mechanism for making recommendations for the aggregate findings on a particular injury problem is needed. The purpose of this chapter is to outline a systematic process for identifying the largest, most severe, and most preventable injury problems and targeting those problems for intervention. An evidence-based approach to identifying problems for which effective prevention strategies exist is described and used as a foundation for

making recommendations that could be applied to the military or other similarly large populations.

1-2. A SYSTEMATIC PROCESS FOR INJURY PREVENTION.

A. THE PUBLIC HEALTH APPROACH.

(1) A comprehensive public health approach for the prevention of injuries has previously been recommended for the Services.^(4, 18, 19) That recommendation entailed establishing the five functional steps of the public health approach for injury prevention listed in Table 1-1.

TABLE 1-1. FUNCTIONAL STEPS OF THE PUBLIC HEALTH APPROACH TO INJURY PREVENTION

Functional Step of Prevention Process	Description of Function
1. Surveillance	Medical and safety surveillance routinely tracks frequencies, rates, and trends in injuries and other health problems. The data are used to identify ongoing and emergent problems and to help set priorities. Surveillance can also help monitor prevention policy and program effectiveness.
2. Research and Field Investigations on Risk Factors and Causes	Research and, to some extent, public health field investigations provide information on the incidence of injuries and other health problems and determine causes and risk factors for health problems.
3. Research on Interventions	Research may also entail conducting intervention trials both randomized and nonrandomized to determine what works to prevent injuries and other health problems. Intervention trials provide information on the efficacy of prevention strategies.
4. Program and Policy Implementation	Policy makers, work-site supervisors, military commanders, and other authorities direct implementation of injury prevention and other public health policies, programs, and strategies to protect populations and communities.
5. Evaluation and Monitoring of Programs and Policies	When policies, programs, and strategies are implemented, a mechanism for evaluating the effectiveness of those activities should be established. Surveillance data can also be used to monitor ongoing effectiveness.

(2) For a large community or organization such as the military to successfully prevent injuries, it is necessary for each of the five functional steps to be operating. Although the approach does not necessarily need to be carried out in sequential order, all the steps are deemed to be necessary in order to successfully prevent injuries over time. Great strides have been made since the initial recommendation of the five-step public health approach to the Armed Forces Epidemiology Board in 1996.⁽¹⁹⁾ Routine medical surveillance of injuries resulting in hospitalization of military Service members, and also those treated in outpatient clinics, has been implemented.⁽¹⁸⁾ Additionally, the means to evaluate public health practices implemented to prevent injuries in military populations has been demonstrated.^(20, 21) The one step for which the least progress has been made is research. While occasional *ad hoc* injury research initiatives arise, at this time there is no dedicated injury prevention research objective or program for the military. Despite great progress for injury prevention in the military to be effective, all of the

steps of the process—including health surveillance—need to be improved for each of the Services.

B. THE EVIDENCE-BASED PROCESS.

(1) EVIDENCE-BASED MECHANISM. In addition to the five steps of the public health approach, cost-effective injury and disease prevention require an evidence-based mechanism for prioritizing prevention activities and allocating public health and prevention resources to problems for which there is scientific evidence of effective prevention policies, programs, or interventions.⁽²²⁻²⁴⁾ Great progress has been made in evidence-based decision making in preventive medicine and public health over the last 20 years in the United States, starting with the U.S. Preventive Services Task Force (USPSTF) in the late 1980s.^(25, 26) As described by Briss and McGinnis, the USPSTF first applied the evidence-based process to the evaluation of clinical preventive services in the Guide to Clinical Preventive Services in 1989.^(26, 27) With the development of the Guide to Community Preventive Services in 2000, that process has now been extended to community public health.⁽²⁵⁻²⁸⁾ The process for identifying successful evidence-based prevention strategies and setting public health and safety priorities has gained enough credence to recommend wide implementation.

(2) SURVEILLANCE. The first step of the evidence-based process is to identify the biggest and most severe health problems affecting a community or population (Table 1-2).^(29, 30) Health and safety surveillance and surveys are the most logical means to identifying the biggest and most severe injury and other health problems of a community. In the past, the public health importance of injuries and other health problems has been established primarily using fatality data.⁽³¹⁾ In the Services, top priorities for injury prevention are still predicated on the leading causes of deaths—motor vehicle and aviation mishaps. The prioritization process should include not just mortality measures but also morbidity measures such as disabilities, hospital discharges, and visits for emergency and other outpatient treatment.^(9, 28, 32) Using fatality data for setting injury prevention priorities can be particularly misleading since the most frequent causes of injuries do not cause death.⁽³³⁾ Also, as highlighted earlier, because the leading causes of injury deaths are different than the leading causes of the more numerous nonfatal injuries, reducing the leading causes of deaths may have little impact on the overall burden of injuries on a population. In the initial phase of identifying the most important injury problems of a community, both magnitude and severity of injuries should be considered using fatality, disability, hospitalization, and outpatient data.

TABLE 1-2. STEPS OF EVIDENCE-BASED PUBLIC HEALTH DECISION-MAKING PROCESS

Step of Process	Description of Step
1. Identification of biggest or most severe problems	The first step of the evidence-based public health process utilizes medical, safety, and other surveillance and survey data sources to identify causes or types of injury with high rates or indicators of severity to target for potential prevention.
2. Search for evidence of effective prevention	The second step of the process uses knowledge of the most significant injury problems confronting a population from step one to focus systematic reviews of the scientific literature on those problems to determine what evidence exists for their prevention.
3. Evaluation of quality of evidence for prevention	The third step of the process evaluates the quality of individual research studies using predetermined criteria to assess strengths and weaknesses of design, execution, and analysis.
4. Recommendations based on strength and consistency of evidence	The fourth step of the process assesses the strength and consistency of the overall evidence that interventions work to prevent the problems identified as a foundation for recommendations. Note: No one study design addresses all the questions requiring answers about effectiveness, harms, and real-world feasibility. One study is not sufficient to make evidence-based recommendations.
5. Prioritization of interventions	The fifth step applies predetermined criteria to rank prevention strategies for allocation of resources and implementation based on the magnitude or severity of a problem, its preventability (evidence of effective interventions), and the feasibility of implementation.
6. Identification of research gaps	The sixth and final step of the evidence-based prevention process can take place concurrently with the fifth. This step identifies gaps in knowledge of what prevents the most significant health problems confronting a population and targets them for more research.

(3) SYSTEMATIC REVIEWS AND THE QUALITY OF EVIDENCE.

(A) In targeting and conducting effective injury prevention, it is not enough to know what the biggest injury problems are. It is also necessary to know which ones are preventable. A process for identifying and evaluating the evidence for what works to prevent injuries is also essential (Step 2, Table 1-2). A number of approaches have been established for evaluating the effectiveness of interventions to treat or prevent health problems. The best known is the process established by the USPSTF, which has been well described elsewhere.⁽³⁴⁻³⁶⁾ Similar processes have been adopted by other groups and organizations.⁽³⁷⁻³⁹⁾ Most recently, a similar process has been adopted by the Guide for Community Preventive Services.^(26, 28) What the Guide for Community Preventive Services and other such evidence-based processes have in common is that they start with a systematic review of the literature using a well defined, pre-established approach to identify potential interventions/countermeasures that have been scientifically evaluated and found effective.

(B) After the literature reviews have been completed, the next step is to assess the quality of the science for identified studies and to characterize the health outcomes associated with the interventions studied and the effect sizes (Step 3, Table 1-2). There is a growing consensus that whether one is assessing the effectiveness of a medication, clinical preventive services, or a

community preventive service, more than just the beneficial effect of an intervention must be considered in making recommendations for prevention. The potential harms of an intervention must be assessed as well.^(24, 36, 37) The process must have: (1) a standardized method of finding evidence to assess, (2) a standard set of considerations in evaluating the quality of individual scientific studies, and then (3) a pre-determined means of arriving at a composite score for each study on a particular prevention strategy that can be compared to other studies. Such systematic reviews (that is, literature reviews coupled with quality assessments) are now viewed as a critical part of the public health decision-making process.^(40, 41)

(C) Completing the search and evaluation process is time consuming and rigorous. As a consequence, Harris et al.,⁽³⁶⁾ in writing about the USPSTF, state that “limited resources and time requires compromises in the intensity of reviews...One strategy is topic prioritization...Another strategy...is to focus the review on the questions and evidence most critical to making recommendations.” This type of process has been applied to setting priorities for military injury prevention and an expedited process for more rapid evaluation by public health and safety organizations has been recommended.⁽⁴²⁾ To facilitate more rapid transmission of evidence-based injury prevention information to decision and policy makers, an expert military panel established an expedited process for scientific study evaluation.⁽⁹⁾ Thus, several approaches can be used to facilitate more rapid transmission of information from evaluators to decision makers including focusing the systematic review process on the most important interventions and expediting the review process itself.

(4) SYSTEMATIC REVIEWS AND THE STRENGTH AND CONSISTENCY OF EVIDENCE.

(A) Following the identification of evidence sources (studies) and the evaluation of the quality of individual studies, the next step is translation of the body of evidence as a whole into recommendations. This step of the evidence-based process (Step 4, Table 1-2) entails the assessment of the overall strength and consistency of the evidence for a particular intervention.^(27, 36, 38) As mentioned earlier, not only must the process evaluate how effective an intervention strategy is at preventing injuries or other health outcomes but also any harms that might arise from implementation of the intervention.^(24, 27, 36, 37, 39) In making recommendations, information on the quality and consistency of evidence that a strategy works must be balanced against potential harms and the costs implementation may impose.

(B) In addition to weighing effectiveness, harms, and costs in the process of making public health recommendations, consideration should be given to what needs to be done in situations when an urgent public health or safety problem exists but there is insufficient scientific evidence of interventions that work to prevent the problem.^(37, 43) In a rating scheme for recommendations by the Strength of Recommendation Taxonomy, Ebell indicates that the lowest level of evidence is consensus or usual practices (that is, expert opinion).⁽³⁸⁾ In his discussion of the USPSTF, Harris warns that if evidence is deemed insufficient to make a recommendation to provide preventive services, then decision makers must rely on factors other than science.⁽³⁶⁾

Claxton addresses the issue directly stating that a method is needed for acquiring “judgments from experts when no evidence is available.”⁽³⁷⁾

(C) With the above considerations in mind, a set of ratings for recommendations has been made that is suitable for use in a large population that frequently confronts new and significant public health and safety problems, many of which may be of an urgent nature (Table 1-3). The proposed categories of recommendations are “strongly recommend,” “recommend,” “no recommendation,” “recommend against use,” “insufficient evidence,” and “expert opinion.” To accommodate the inevitable situation that the military and other organizations will need recommendations for intervention when no evidence of preventability exists, the category for expert opinion was added. It should be noted, however, that when interventions without clear evidence of effectiveness are implemented they should be carefully evaluated.

TABLE 1-3. LEVELS OF RECOMMENDATIONS FOR INJURY PREVENTION STRATEGIES

Recommendation	Reasons for Recommendation
Strongly Recommend	Good data on effectiveness exists, some of it high quality and findings across studies are consistent. Effect sizes are substantial.
Recommend	At least fair evidence of intervention effectiveness exists and findings of effectiveness are mostly consistent. Effect sizes may be modest.
No Recommendation	Benefits and harms too close to make a recommendation.
Recommend Against Use	Data from studies of adequate sample size to show intervention effects of modest magnitude do not indicate that the intervention is effective or the harms of the intervention outweigh the benefits.
Insufficient Evidence	Insufficiency of evidence may result from a complete lack of data, few studies, or inconsistency of results.
Expert Opinion	In the absence of scientific evidence on the effectiveness of interventions (e.g., insufficient evidence), utilization of expert opinion or consensus opinions on recommendations for prevention may be warranted for urgent health problems. When the basis for an intervention is expert opinion, the intervention implemented should be rigorously evaluated and closely monitored for effectiveness.

(5) STUDY DESIGN AND TRADE-OFFS IN VALIDITY OF EVIDENCE.

(A) An issue of importance to the process of evaluating the quality and strength of evidence supporting prevention is that of study type or design. In the past, the only acceptable standard was randomized controlled trials (RCTs). There is, however, a growing consensus that RCTs are not necessarily the only acceptable standard or even the gold standard, especially for nonpharmaceutical, nonclinical, community-based interventions.^(24, 37, 39, 44, 45) Even the USPSTF has started to rethink its previous bias towards RCTs.⁽³⁶⁾ This consensus has arisen from the growing awareness of the shortcomings of RCTs in documenting the harms or adverse outcomes of interventions, the inability to provide an accurate assessment of the magnitude of health benefits of an intervention in a nonexperimental setting, and impracticality of conducting randomized studies in many circumstances. While RCTs may have greater internal validity, they lack the external validity offered by other study designs. For instance, Atkins et al.,⁽⁴³⁾ state that

RCTs “may not give an accurate picture of the impact of a policy decision under real-world conditions.”

(B) Because of time and funding constraints, RCTs frequently employ intermediate outcomes. This is not acceptable. Several authors caution that in determining the effectiveness of an intervention, it is essential that the health outcomes of interest be assessed,^(24, 43) unless the link between an intermediate outcome and the occurrence of the health outcome of interest is well established (such as, the link between seat belt use and decreased risk of traffic fatalities).

(C) A variety of valid alternative nonrandomized study designs may be useful in assessing the effectiveness of interventions intended to be implemented on a wide scale in communities and populations. These study types include nonrandomized prospective and retrospective cohort studies, pre-post studies, time-series, case control, and natural experiments, as well as other quasi-experimental or observational types of studies.^(24, 44, 45) Teutsch notes that data from RCTs is scarce for many interventions, so investigators should not be deterred from using other more practical study designs.⁽²⁴⁾ What is important in choosing a study design is that it be able to determine whether implementation of an intervention changed the incidence of the health outcome of interest. Furthermore, Mercer et al.,⁽⁴⁴⁾ state, “No one study establishes causality,” while Atkins et al.,⁽⁴³⁾ caution that “policy-makers should be skeptical of evidence derived from a single study.” The fact that no one study or study type is an adequate basis for policy and public health decisions argues for greater use of systematic reviews, since systematic reviews make use of all available evidence regardless of study type, published or unpublished.^(43, 45) Consistent outcomes from multiple studies make a better foundation for evidence-based health and public health policy. Weighing evidence from multiple studies of different types provides a greater opportunity to balance effectiveness against harms and costs. The strength of RCTs is that they provide confidence that study findings are not due to chance or bias resulting from inadequate study design (that is, internal validity), while other types of well-designed studies may be more practical, less costly, and more generalizable (that is, external validity).

(6) SETTING PRIORITIES FOR PREVENTION IN THE EVIDENCE-BASED PROCESS. The process of evidence-based decision making in public health does not end with the identification of the biggest, most severe health conditions, such as falls or motor vehicle-related injuries. The process also does not end with recommendations for prevention based on systematic reviews of the quality and consistency of the scientific evidence. In addition to this knowledge, what is needed is a systematic process for setting prevention priorities. The need for a mechanism for setting priorities for allocation of resources for prevention of injuries and disease is widely recognized.^(16, 22-24, 30, 32, 37, 46-49) The Institute of Medicine Committee on Injury Prevention and Control stated that for injury prevention “Whatever the overall level of public investment... priorities for research and social action must be set. The challenge facing the field is developing criteria for setting these priorities.”⁽³⁰⁾

(A) **CRITERIA FOR SETTING PRIORITIES.** A number of approaches to establishing prevention priorities employing a variety of criteria have been suggested, including using the burden of disease,⁽³⁵⁾ consideration of the magnitude, severity, and costs of problems,^(46, 50) or these in combination with preventability/effectiveness⁽¹⁶⁾ and other feasibility factors such as acceptability, available resources, and legal authority.^(22, 23, 47, 51) Runyan⁽²³⁾ and Fowler⁽²²⁾ have described more comprehensive criteria than others, including decision matrices specifically designed for setting injury prevention priorities. Their criteria for setting injury prevention priorities (Table 1-4) and other sources can be aggregated into several overarching categories including effectiveness (preventability considering benefits and harms), costs, feasibility (funding, infrastructure, personnel, legal authority), acceptability (social and political), and sustainability.

TABLE 1-4. CRITERIA FOR SETTING INJURY PREVENTION PRIORITIES

Criteria from Runyan⁽²²⁾ based on Public Health and Policy Analysis	Criteria from Fowler⁽²¹⁾ based on Public Health Approach
Effectiveness	Effectiveness
Cost	Cost
Feasibility	Feasibility
Acceptability <ul style="list-style-type: none"> • Preferences • Freedom • Equity • Stigma 	Acceptability <ul style="list-style-type: none"> • Political acceptability • Social will
Other	Sustainability
—	Potential for unintended consequences

(B) **PROCESS FOR SETTING PRIORITIES BASED ON CRITERIA.** Once criteria are established for setting priorities, a process for ranking of the potential priorities identified must be developed. Fowler⁽²²⁾ described a qualitative process using rankings of “high,” “moderate,” and “low” ascribed to each criterion in a decision matrix. Runyan⁽²³⁾ suggested that either qualitative or quantitative methods for applying criteria can be employed to set priorities since what is most necessary is that decision makers consider the most important factors likely to determine policy, program, or intervention success. Claxton et al.,⁽³⁷⁾ expressed a preference for a quantitative approach to such decision making, stating, “In particular, evidentiary criteria are not tied formally and quantitatively to benefits, risks, and costs associated with an intervention and as a result do not maximize health benefits.” As a consequence of this kind of thinking, several military injury prevention work groups have adopted a quantitative approach to setting priorities.^(9, 42, 52) The criteria employed by these military work groups and the scoring of criteria are provided in Table 1-5.

TABLE 1-5. PRIORITY-SETTING CRITERIA EMPLOYED BY MILITARY INJURY PREVENTION WORK GROUPS

Criterion	Scoring
A. PROGRAM OR POLICY IS CONSISTENT WITH MISSION OF THE WORK GROUP/ORGANIZATION	If YES – Continue with scoring. If NO – Stop here.
B. IMPORTANCE OF PROBLEM TO FORCE HEALTH AND READINESS <i>Considerations:</i> <ol style="list-style-type: none"> 1. Magnitude of the problem (e.g., frequency, incidence). 2. Severity of the problem (consider its effect on personnel readiness). 3. Cost of the problem (consider training, property, and personnel costs). 4. Size of population at risk. 5. Degree of concern (consider command concern, public and Service member concern, visibility of problem). 	(10 points; 1=low, 10=high)
C. PREVENTABILITY OF PROBLEM <i>Considerations:</i> <ol style="list-style-type: none"> 1. Cause(s) are identifiable. 2. Risk factors are modifiable. 3. Proven prevention strategies that exist to reduce existing injury rates. 4. Prevention strategies that reduce existing injury rates can be designed. 5. Effect size. 	(10 points; 1=low, 10=high)
D. FEASIBILITY OF PROGRAM OR POLICY <i>Considerations:</i> <ol style="list-style-type: none"> 1. Existence of infrastructure to support implementation and sustainability of the program or policy (consider medical staff and facilities, safety staff and resources, cadre availability). 2. Perceived adequacy of funding to support implementation and sustainability. 3. Authority to implement and sustain the program or policy is held or obtainable by the implementing organization(s). 4. Program or policy will not undermine essential missions. 5. Political and cultural acceptability of program or policy. 6. Accountability and responsibility for implementation and sustainability exists or can be established. 	(10 points; 1=low, 10=high)
E. TIMELINESS <i>Considerations:</i> <ol style="list-style-type: none"> 1. Time to implementation. 2. Time to results. 	(5 points; 1=low, 5=high)
F. EVALUATION OF PROGRAM OR POLICY <i>Considerations:</i> <ol style="list-style-type: none"> 1. Ability to evaluate effects of program or policy exists (consider if a metric is possible). 2. Benefits of program or policy outweigh the costs of implementation and sustainability. 3. Collateral benefits as a result of implementation (i.e., increased readiness, decreased attrition, and decreased other health problems). 	(5 points; 1=low, 5=high)

(C) **CRITERIA FOR SETTING RESEARCH PRIORITIES.** A similar set of criteria to those for setting prevention priorities can be used to set research priorities. In 2002, a preliminary set of such criteria was developed by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) and the Johns Hopkins Center for Injury Research and Prevention (Table 1-6).⁽⁵²⁾ In setting injury prevention and other public health prevention priorities, a primary criterion is scientific evidence that effective interventions exist. On the other hand, a primary criterion for setting research priorities is that adequate evidence of effective interventions does not exist. Thus, the most obvious evidence that research is needed is when a large problem is identified but no research is found to support prevention. The most efficient way to set both prevention and research priorities may be to conduct both prioritization processes at the same time, since the process for identifying important, preventable injuries will be the same and the criteria for setting priorities will be similar.

TABLE 1-6. SUGGESTED PRIORITY-SETTING CRITERIA FOR MILITARY RESEARCH

A. Program or Policy is Consistent with Mission of the Work Group/Organization
B. Importance of Problem to Force Health and Readiness <i>Considerations:</i> <ol style="list-style-type: none"> 1. Magnitude and severity of problem 2. High costs of problem 3. Size and/or vulnerability of population at risk 4. Degree of concern (command or public) 5. Gaps in knowledge of effective prevention strategies, or modifiable causes and risk factors exist 6. Military uniqueness
C. Potential Value of Research <i>Considerations:</i> <ol style="list-style-type: none"> 1. Cross-cutting (cuts across types of injury) 2. Likelihood of identifying discrete modifiable risk factors 3. Demonstrated preventability in civilian population
D. Feasibility of Research Program or Project <i>Considerations:</i> <ol style="list-style-type: none"> 1. Preventive medicine and medical infrastructure exist to support research efforts 2. Research partners exist 3. Technologic feasibility of doing research (ability to collect data) 4. Adequacy of resources

1-3. CONCLUSIONS AND RECOMMENDATIONS.

A. The problem of injuries for the military is large enough and costly enough to warrant the time and resources needed to conduct a systematic, data-driven, and evidence-based process of prevention. To effectively implement such a process, all the functional capabilities/steps of the public health approach listed in Table 1-1 will be necessary. While the infrastructure needed for successful injury prevention for each of the functional capabilities exists within the Department of Defense (DOD), each of the steps needs to be greatly strengthened. Currently, the strongest element of a comprehensive injury prevention system is medical and safety surveillance. Current medical and safety surveillance data are adequate to identify significant military injury problems and to monitor changes in rates of injuries over time following implementation of interventions,

programs, or policies. A significant limitation of current medical surveillance capabilities is the lack of cause coding for outpatient encounters.

B. In regard to getting prevention information to those who need to know, the infrastructure for disseminating injury prevention information is readily available through the military Service safety centers and chains of command. Likewise, once the effectiveness and feasibility of an injury prevention strategy has been demonstrated, the infrastructure and mechanisms exist within the military to rapidly implement the strategy.

C. The ability to evaluate programs and document success at the installation and Service level has been demonstrated,^(20, 21) but human and fiscal resources for this essential public health service are limited. In addition, despite the fact that several initiatives have employed an evidence-based approach to making recommendations for injury prevention and setting priorities, the process has not been institutionalized in the military.^(9, 42) Finally, the weakest step in the process for the DOD is research. Even though injuries are the single biggest health problem of all of the Services, there is currently no specific injury prevention scientific or technical objective to which resources can be routinely applied, with the exception of occasional monies directed to address *ad hoc* problems. Without systematic injury research, progress with injury prevention will stop once off-the-shelf solutions have been exhausted.

D. Finally, the weakest step in the process for the DOD is research. Even though injuries are the single biggest health problem of all of the Services, there is currently no specific injury prevention scientific or technical objective to which resources can be routinely applied, with the exception of occasional monies directed to address *ad hoc* problems. Without systematic injury research, progress with injury prevention will stop once off-the-shelf solutions have been exhausted

E. With the above considerations in mind, the following recommendations are made to establish a comprehensive, evidence-based approach to military injury prevention:

(1) Use readily available military surveillance databases (such as, deaths, disabilities, hospitalization, outpatient, and safety) to identify the largest and most severe military injury problems.^(4, 18)

(2) Commission systematic reviews of prevention and safety literature to determine what has been shown to work for the prevention of the largest, most serious military injury problems.

(3) Establish committees of medical and safety subject matter experts to routinely access and set priorities for military injury prevention.

(4) Implement proven prevention strategies in a prioritized manner.

(5) Evaluate effectiveness of all implemented policies, programs, and interventions/countermeasures.

(6) Where information on effectiveness does not exist or is insufficient to make evidence-based recommendations, empanel subject matter experts to make best-practice recommendations for serious injury problems.

(7) Commission research for large injury problems for which evidence for prevention does not exist or is inadequate.

(8) Establish routine channels for disseminating information to ensure that key stakeholders receive the information and training necessary to effectively reduce the impact of injuries on the health and readiness of military personnel.

F. In following the above recommendations, the Services and DOD have an opportunity to not only significantly reduce the incidence of injuries to Service members but also to establish a model for public health practice for military and civilian communities.

G. The chapters that follow this introduction to the systematic evidence-based process of injury prevention will illustrate—

(1) How priorities can be set using military surveillance and research data.

(2) How surveillance data can be used to identify and monitor injury problems for the military.

(3) How systematic reviews can be employed to provide military-relevant information on what works to prevent injuries.

(4) Some of the results of military injury prevention program evaluations and research.

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CHAPTER 2

RESULTS OF A SYSTEMATIC PROCESS TO
PRIORITIZE MILITARY PREVENTION ACTIVITIES

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2-1. INTRODUCTION.

A. Historically, public health policy development has been driven by high-visibility, emotion-invoking issues of public concern rather than “a careful assessment of existing knowledge, establishment of priorities based on data, and allocation of resources according to an objective assessment of the possibilities for greatest impact.”⁽¹⁾ While responding to issues with immediate public health concern will always be a necessary component of public health practice and policy, sustained progress toward the reduction or prevention of leading health problems requires a more systematic approach. This approach should be based on a review of available epidemiologic data and evaluation of the scientific evidence on existing or potential prevention strategies.

B. In the injury prevention field, expert opinion has been used to guide priority setting in the past.^(2, 3) At least one scoring system has been developed for use in injury prevention priority setting that provides an objective, quantitative assessment of injury frequency and severity.⁽⁴⁾ However, determining the magnitude of the injury problem is only part of what must be considered when deciding what programs and policies to implement. Information on the effectiveness of prevention strategies, gathered from systematic reviews or existing studies, should also be considered. Additionally, political, social, and economic factors contribute to the success or failure of a public health program or policy. The 1999 Institute of Medicine report, *Reducing the Burden of Injuries*, called for the use of criteria for setting injury prevention priorities.⁽⁵⁾ While many of the factors mentioned above have been incorporated into suggested criteria to evaluate injury programs and policies,^(6, 7) there are no published descriptions of applications of these criteria.

C. This chapter describes the application of a prioritization process that incorporates the review of fatal and nonfatal epidemiologic data and the use of pre-determined criteria and scoring to obtain an objective and quantitative assessment of the degree to which the leading causes of injury are amenable to program and policy implementation in the U.S. Department of Defense (DOD). This work built upon two prior injury prioritization efforts: one that generated injury prevention priorities for the Injury Prevention Program of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM),^(8, 9) and another that produced injury prevention priorities for the DOD.⁽¹⁰⁾ The goal of the prioritization initiative described in this paper was to refine the previous efforts and obtain input from experts with public health training and experience evaluating epidemiologic data and the scientific literature.

2-2. METHODS.

A. This initiative began in April 2006 with the formation of the Military Injury Epidemiology and Prevention Priorities Working Group (MIEPPWG), which was established under the Military Training Task Force of the Defense Safety Oversight Council. The MIEPPWG consisted of 18 faculty and graduate student volunteers from the Uniformed Services

University of the Health Sciences (USUHS). Its mission was to review and assess existing medical surveillance and research data to identify the largest and most preventable DOD injury problems that, if addressed, had the greatest potential to rapidly reduce overall injury rates.

B. Working group members were provided data from the Defense Medical Surveillance System⁽¹¹⁾ on overall rates and causes of non-battle injury, both fatal and nonfatal, among Active Duty military personnel between 2003 and 2005. Previously established criteria for prioritizing injury programs and policies⁽⁸⁻¹⁰⁾ were adopted for use by the MIEPPWG. Instructions for the use of the criteria were provided in-person, on the worksheets used for scoring, and as needed through follow-up electronic mail communications. Working group members reviewed the medical surveillance data, then independently applied the criteria to each of the following leading causes of military injury hospitalizations: falls/jumps, privately owned vehicle accidents, physical training, sports, guns/explosives, military parachuting, twists/turns/slips without fall, military vehicle accidents, nontraffic motor vehicle accidents, and machinery/tools. Cause categories were consistent with standard military injury cause coding used by North Atlantic Treaty Organization countries.⁽¹²⁾ These ten causes were identified from medical surveillance data as the leading causes of injury hospitalizations among Active Duty military personnel in 2004.^(11, 13)

C. The worksheet and criteria used by working group members to rate each injury cause is shown in Figure 2-1. The process was conducted individually and first required consideration of whether adoption of programs or policies related to the injury issue was consistent with the mission of the entity applying the scoring criteria (that is, the working group's mission). Next, a preliminary rating of low, medium, or high was assigned to 21 "considerations" within the following five main criteria: (1) importance of the problem, (2) preventability, (3) feasibility, (4) timeliness, and (5) evaluation potential. Preliminary ratings of each consideration were then considered when determining a final numerical score for the main criterion, which ranged from 1 to 10 for those criteria given a higher "weight" in the process (importance of the problem, preventability, and feasibility) and 1 to 5 for those criteria given a slightly lower weight (timeliness and potential to evaluate). Weights were adopted from previous work.⁽⁸⁻¹⁰⁾

Instructions: Complete a scorecard for each injury problem under consideration. First, provide a *preliminary rating* for each of the *Considerations* listed under each criterion. Then, using the preliminary ratings as a guide, assign a **final score** for each criterion. For criteria B, C, and D, assign a final score from 1-10 (1 = lowest score, 10 = highest score). For criterion E, assign a final score from 1-5 (1 = lowest score, 5 = highest score). Adding the final scores will provide a *total score*. A perfect score on all criteria would result in a total score of 40.

Criterion	Preliminary Rating	Final Score
A. PROGRAM OR POLICY IS CONSISTENT WITH MISSION OF THE WORKING GROUP Reduce injury rates by 50 percent	<input type="checkbox"/> YES <input type="checkbox"/> NO	If YES – Continue with scoring. If NO – Stop here.
B. IMPORTANCE OF PROBLEM TO FORCE HEALTH AND READINESS (10 points) <i>Considerations:</i> 1. Magnitude of the problem (e.g., frequency, incidence). 2. Severity of problem (consider its effect on personnel readiness). 3. Cost of the problem (consider training, property, and personnel costs). 4. Size of population at risk. 5. Degree of concern (consider command concern, public and Service member concern, visibility of problem).	1. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 2. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 3. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 4. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 5. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High	(10 points; 1=low, 10=high)
C. PREVENTABILITY OF PROBLEM (10 points) <i>Considerations:</i> 1. Cause(s) are identifiable. 2. Risk factors are modifiable. 3. Proven prevention strategies that reduce existing injury rates exist. ^a 4. Prevention strategies that reduce existing injury rates can be designed. 5. Effect size.	1. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 2. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 3. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 4. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 5. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High	(10 points; 1=low, 10=high)
D. FEASIBILITY OF PROGRAM OR POLICY (10 points) <i>Considerations:</i> 1. Existence of infrastructure to support implementation and sustainability of the program or policy (consider medical staff and facilities, safety staff and resources, cadre availability). 2. Perceived adequacy of funding to support implementation and sustainability. 3. Authority to implement and sustain the program or policy is held or obtainable by the implementing organization(s). 4. Program or policy will not undermine essential missions. 5. Political and cultural acceptability of program or policy. 6. Accountability and responsibility for implementation and sustainability exists or can be established.	1. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 2. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 3. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 4. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 5. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 6. <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High	(10 points; 1=low, 10=high)

FIGURE 2-1. CRITERIA FOR PRIORITIZING INJURY PROGRAMS AND POLICIES

Criterion	Preliminary Rating	Final Score
E. TIMELINESS (5 points) <i>Considerations:</i> <ol style="list-style-type: none"> Implementation time.^b Results time.^b 	<ol style="list-style-type: none"> <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 	(5 points; 1=low, 5=high)
F. EVALUATION OF PROGRAM OR POLICY (5 points) <i>Considerations:</i> <ol style="list-style-type: none"> Ability to evaluate effects of program or policy exists (consider if a metric is possible). Benefits of program or policy outweigh the costs of implementation and sustainability. Collateral benefits as a result of implementation (i.e., increased readiness, decreased attrition, and decreased other health problems). 	<ol style="list-style-type: none"> <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High <input type="checkbox"/> Low <input type="checkbox"/> Medium <input type="checkbox"/> High 	(5 points; 1=low, 5=high)
TOTAL SCORE		

Notes:

^a If systematic reviews substantiate effectiveness of a prevention strategy, score as 10 points automatically.

^b Assign shorter implementation and response times a higher rating.

FIGURE 2-1. CRITERIA FOR PRIORITIZING INJURY PROGRAMS AND POLICIES (CONTINUED)

D. Scores were analyzed using two methods. The first method ranked injury causes using the total mean score of each injury cause. The second method ranked injury causes using total scores calculated by the Multiple Attribute Decision Making (MADM) method.⁽¹⁴⁾ Using MADM, for each cause, median scores for each of the five main criteria were normalized. Normalized scores were multiplied by a weight reflecting the importance of the criterion. Criterion of equal importance (such as, all criteria with a maximum score of 10 and both criteria with a maximum score of 5) were given the same weight. The normalized, weighted criteria scores were summed for each cause. This sum, or final total score, was used to rank the causes of injury. With both methods, the higher the score, the stronger the indication that the injury problem was amenable to program and policy implementation.

2-3. RESULTS.

A. Nine members of the working group (50 percent) volunteered to participate in the full prioritization process. Members who contributed to the prioritization process were formally trained in public health and represented the disciplines of behavioral science, preventive medicine/epidemiology, occupational medicine, family medicine, sports medicine, and military medicine.

B. The highest possible total mean score was 40 points. Injury causes with the highest total mean scores were as follows: physical training (32.2 points), privately owned vehicle accidents (29.8 points), military parachuting (29.4 points), sports (29.0 points), and military vehicle accidents (28.1 points) (Table 2-1). Compared to all other causes, physical training had the highest mean scores for importance of the problem (8.8/10 points), preventability (8.1/10 points), and feasibility (7.2/10 points). Military parachuting had the highest score for timeliness (4.1/5 points) compared to all other causes; it was tied with physical training for the highest score on evaluation potential (4.3/5 points). The second leading injury cause, privately owned vehicle accidents, scored lower than the third leading cause, military parachuting, on all but one criterion (importance of the problem).

C. The lowest mean scores on the importance criterion were seen for military parachuting and tools and machinery (5.7/10 points). The lowest mean score for preventability was seen for twists/turns (4.9/10 points). Nontraffic vehicle accidents and twists/turns received the lowest mean score for feasibility (5.3/10 points). Nontraffic vehicle accidents also received the lowest mean score for timeliness (2.6/5 points), and twists/turns received the lowest mean score for evaluation potential (2.5/5 points).

TABLE 2-1. MEAN SCORES FOR FIVE MAIN CRITERIA, MEAN TOTAL SCORE, AND RANK ORDER BY CAUSE OF INJURY

Causes of Injury	Importance (mean) ^a	Preventability (mean) ^a	Feasibility ^a (mean)	Timeliness ^b (mean)	Evaluation Potential ^b (mean)	Total Score (mean) ^c	Rank by Total Score
Physical training	8.8	8.1	7.2	3.8	4.3	32.2	1
Privately owned vehicle accidents	8.3	7.9	6.6	3.1	3.9	29.8	2
Military parachuting	5.7	8.7	6.7	4.1	4.3	29.4	3
Sports	7.6	7.2	6.4	3.7	4.1	29.0	4
Military vehicle accidents	7.6	7.4	6.3	3.0	3.7	28.1	5
Guns and explosives	6.9	7.1	6.4	3.6	3.6	27.6	6
Falls	7.1	6.6	6.3	4.0	3.6	27.0	7
Tools and machinery	5.7	6.8	6.4	2.7	3.5	25.1	8
Nontraffic vehicle accidents	6.2	6.1	5.3	2.6	3.1	23.3	9
Twists/turns (without fall)	6.1	4.9	5.3	2.8	2.5	21.5	10

Notes:

^a Maximum score = 10.^b Maximum score = 5.^c Maximum score = 40.

D. The highest possible score using the MADM method was 100. Physical training received the highest score (85.1), followed by military parachuting (79.7), privately owned vehicle accidents (77.7), sports (72.3), falls (67.4), and military vehicle accidents (67.4) (Table 2-2). Physical training and privately owned vehicle accidents had the highest median score (9/10 points) for importance of the problem. Military parachuting had the highest median score (10/10 points) for preventability of the problem and evaluation potential (5/5 points). Physical training and tools and machinery had the highest median scores (8/10 points) for feasibility and physical training, military parachuting, and sports had the highest median scores (4/5 points) for timeliness.

E. Tools/machinery and nontraffic vehicle accidents had the lowest median score for importance of the problem (5/10 points). Twists/turns had the lowest median score, compared to all other causes, for both preventability and feasibility (5/10 points). Tools/machinery and

nontraffic vehicle accidents had the lowest median score for timeliness (2/5 points) and four injury causes (that is, guns/explosives, tools/machinery, twists/turns, nontraffic vehicle accidents) received the lowest median score for evaluation potential (3/5 points).

TABLE 2-2. SCORES FOR FIVE MAIN CRITERIA, TOTAL SCORE, AND RANK ORDER BY CAUSE OF INJURY USING THE MULTI-ATTRIBUTE DECISION-MAKING PROCESS

Causes of Injury	Importance ^a (median)	Preventability ^a (median)	Feasibility ^a (median)	Timeliness ^b (median)	Evaluation Potential ^b (median)	MADM Score ^c	Rank
Physical training	9	9	8	4	4	85.1	1
Military parachuting	6	10	7	4	5	79.7	2
Privately owned vehicle accidents	9	8	7	3	4	77.7	3
Sports	7	7	7	4	4	72.3	4
Falls	7	7	6	3	4	67.4	5
Military vehicle accidents	7	7	6	3	4	67.4	5
Guns and explosives	7	7	6	3	3	65.1	7
Tools & machinery	5	6	8	2	3	60.3	8
Twists/turns (without fall)	6	5	5	3	3	54.9	9
Nontraffic vehicle accidents	5	6	4	2	3	50.0	10

Notes:

^a Maximum score = 10.

^b Maximum score = 5.

^c Maximum score = 100.

2-4. DISCUSSION.

A. This chapter describes a process that produces a prioritized list of injury causes that can be used to inform and guide public health practitioners and policymakers interested in prioritizing program and policy implementation. Results of an application of this process indicated that the top three injury causes most amenable to DOD program and policy interventions were physical training, privately owned vehicle accidents, and military parachuting. The MADM analysis method returned the same top three priorities, though in a different rank order.

B. The emergence of physical training as the top priority for program and policy intervention is not surprising. Investigations of U.S. Army Active Duty populations have shown physical training-related injuries to be the leading cause of outpatient injuries, accounting for 24 to 50 percent of all outpatient injury visits in operational (nontrainee) units.⁽¹⁵⁻¹⁹⁾ Extrapolating these results to all Service branches, with over 1.9 million injury-related medical encounters affecting over 890,000 Service members annually,⁽²⁰⁾ would amount to 471,000–981,000 physical training-related injury encounters each year. This is a conservative estimate; however, as surveillance of selected lower extremity overuse injuries attributable to physical training activities has indicated that these training-related injuries account for 50–80 percent of the total injury burden for each Service.⁽²¹⁾ These numbers demonstrate that the frequency and incidence of the problem, as well as the size of the population affected, is large. Preventability of physical training-related injuries was rated high because there are several proven prevention strategies, tested in military populations, which could be adopted immediately to address the problem.^(22, 23) Such evaluations also demonstrate the potential for evaluation.

C. Given that motor vehicle accidents have historically been a leading cause of mortality and morbidity among military Service members,^(24, 25) it may not be surprising that privately owned vehicles ranked second in the final list of priorities. Each year, “land transport” is noted as a leading cause of DOD injury hospitalizations, representing 13.8 to 21.1 percent of all injury hospitalizations (2000–2006) with a valid injury cause code.⁽²⁶⁻³²⁾ Safety data has also indicated that 59 percent, 64 percent, 61 percent, and 55 percent of unintentional injury deaths for the Army, Navy, Marine Corps, and Air Force, respectively, were due specifically to privately owned vehicle accidents.⁽³³⁾ Based on these and other statistics, privately owned vehicle accidents scored high on the ‘importance of the problem’ criterion. The availability of systematic reviews of prevention strategies⁽³⁴⁻³⁶⁾ contributed to its high preventability score. High scores on both of these measures—importance and preventability—ultimately contributed to the high ranking of privately owned vehicle accidents in the prioritization process.

D. Military parachuting injuries can be severe and numerous;⁽³⁷⁾ however, they affect a relatively small subset of the military and, as a result, this injury cause scored lower than other causes on the importance of the problem. Evaluations have demonstrated that an effective prevention measure exists, an external parachute ankle brace, which can contribute immediately to reductions of 5 to 80 percent of the most common injuries among airborne personnel: ankle sprains and fractures.⁽³⁸⁻⁴⁰⁾ This combination of factors leads to high preventability and timeliness scores. Ankle injury risk has been shown to be nearly 2 times higher among paratroopers who did not wear an ankle brace compared to those who did wear a brace.⁽⁴¹⁾ These evaluations also demonstrate that it is feasible to implement and evaluate the effects of this intervention in military populations, contributing to higher feasibility and evaluation potential scores. The high preventability, feasibility, timeliness, and evaluation scores in the prioritization process resulted in a high ranking for this injury issue.

E. Of note, falls did not rank as one of the top three injury program and policy priorities, despite annual documentation showing falls as the leading cause of Active Duty military injury hospitalizations, accounting for approximately one-quarter of all injury hospitalizations each year.⁽²⁶⁻³²⁾ This is partially explained by the lack of evaluated interventions in the literature for the prevention of falls among working-age adults, which thus resulted in a low ‘preventability’ score. This ranking could change as work-related fall prevention research identifies effective prevention strategies.

F. The prioritization process described had a number of strengths. First, it was resistant to the influence of individual opinion and political pressure. Objectivity was built into the process by requiring the review of available epidemiologic data to rate the importance of the problem and in the use of a worksheet, which forced consideration of all predetermined criteria and enhanced the visibility of working group members’ ratings and final scores. Second, as has been recommended,⁽⁵⁾ the data reviewed were not limited to mortality data. Rather, working group members also reviewed and formulated their rating based on data on the more numerous nonfatal injuries and their causes. Third, the criteria were comparable to those suggested or used elsewhere^(6, 7, 42-44) and, as has been the case in other rating systems for public health programs,^(42, 43) the criteria covered a wide range of key factors known to influence the success or failure of program and policy efforts. Finally, the scoring system provided a simple and straightforward mechanism to weight and rate those key factors. These criteria and weights could be easily modified to suit the specific needs and considerations of other communities. The criteria could also serve as a template for the development of criteria to prioritize injury prevention research. Criteria to prioritize research would include similar considerations such as the magnitude and severity of the problem and adequacy of resources, but would also consider the existence of gaps in knowledge, availability of research partners, and so forth. (See Chapter 1 for suggested criteria to prioritize research.)

G. Opportunities for improvements to the process include holding an initial in-person meeting prior to use of the criteria and worksheet, so that methods and definitions can be discussed and redefined as necessary. The objectivity of the process could be further enhanced by requiring evidence of program effectiveness from the literature (such as, systematic reviews of prevention measures) rather than relying on expert opinion to define preventability. Preventive medicine and public health, like clinical medicine, has become increasingly focused on identifying evidence-based practices for implementation.⁽⁴⁵⁾ Although, as Runyan noted in her 1998 article, “it isn’t always possible to conduct a rigorous scientific analysis [such as a systematic review] in the timeframe required for program development.”⁽⁷⁾

H. In summary, this process was designed to produce a list of injury prevention priorities through a systematic and objective rating of the degree to which the leading causes of DOD injuries were amenable to program and policy implementation. For public health organizations, establishing data-driven priorities can provide a focus for work and continued progress toward

injury reduction goals when not responding to urgent public health concerns. The process is not limited to use in the injury prevention field, however. The criteria and worksheet could be adapted and applied to prioritize implementation of other public health programs and policies. Such systematic approaches to prioritizing scarce public health resources are necessary, as Dr. William Haddon, Jr. expressed, so that we avoid “inappropriate choices of emphasis” that “dissipate funds, time, and public concern that might be applied to more effective measures.”⁽⁴⁶⁾

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CHAPTER 3

U.S. MILITARY INJURY SURVEILLANCE:
OVERVIEW AND SELECTED INJURY ISSUES

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3-1. MEDICAL SURVEILLANCE OF INJURIES IN THE U.S. MILITARY: UTILITY, COMPARABILITY, AND RECOMMENDATIONS.

A. INTRODUCTION.

(1) Surveillance is the first and most important step of the public health process.⁽¹⁻⁴⁾ As stated by William Foege in his foreword for the second edition of *Principles of Public Health Surveillance*, "...epidemiology and analysis cannot be superior to the surveillance system used for collecting the facts analyzed. The analysis of those facts, the interpretation of their health implications, the interventions designed, and the programs launched are all based on the quality of the surveillance system used. Surveillance systems are therefore basic to everything that follows in public health."⁽⁵⁾

(2) Injury surveillance is critical to sustained injury prevention for a number of reasons^(1, 6, 7) including—

- (a) Identification of the biggest, most severe injury problems.
- (b) Detection of emerging injury problems.
- (c) Setting objective, data-driven priorities.
- (d) Evaluation of newly implemented policies and programs.
- (e) Monitoring continuing success of policies and programs.

(3) Where injury prevention is concerned, it is important to keep in mind that if you cannot measure the health outcome, you cannot prevent it with any certainty.^(7, 8)

(4) In the past, public health surveillance of injuries has focused primarily on fatalities,⁽⁹⁾ but that is not adequate since the vast majority of injuries are nonfatal. In Western European countries and the United States, for every one death there are approximately 30 hospitalizations and 300 emergency department (ED) visits.⁽⁹⁾ The military is no exception to this observation. In the U.S. military, for each unintentional injury death, 33 injury hospitalizations and almost 4,000 outpatient visits have been documented.⁽¹⁰⁾ For this reason, it is strongly recommended that injury surveillance systems capture both morbidity and mortality. At a minimum, injury deaths and hospitalizations should be monitored.⁽¹¹⁻¹⁴⁾

(5) The Department of Defense Injury Surveillance and Prevention Work Group⁽¹⁾ and the Armed Forces Epidemiological Board (AFEB) Work Group⁽²⁾ strongly recommended medical surveillance of nonfatal injuries. Only hospital data was readily available for use in

surveillance at the time of those recommendations in the late 1990s. Now the U.S. Services maintain rapidly accessible hospitalization and outpatient data.

(6) The purposes of this section are to: (1) illustrate progress with medical surveillance of injuries by the military, (2) show the magnitude and causes of the problem of injuries for U.S. Services using routinely available medical data, and (3) make recommendations to improve military medical surveillance systems and the injury prevention process.

B. METHODS.

(1) The population for the analyses in this paper encompassed all Active Duty military personnel for the Army, Air Force, Navy and Marines from 1 January 2000 to 30 December 2006. Most of this report section will focus on data for the most recent year of complete data, 2006. Table 3-1-1 shows the populations for each of the four Services in person-years corrected for time spent deployed to Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). This was done because the medical surveillance data (cases) include only injuries or other health conditions not treated in deployed settings.

TABLE 3-1-1. POPULATION FOR ACTIVE DUTY DEPARTMENT OF DEFENSE AND SERVICES BY YEAR, 2000–2006^a

Year	Department of Defense	Army	Navy	Air Force	Marines
2000	1,352,932	467,222	364,086	350,803	170,821
2001	1,334,640	464,229	358,233	341,362	170,817
2002	1,305,995	455,415	349,181	334,757	166,641
2003	1,164,209	347,316	339,719	332,336	144,838
2004	1,197,679	353,693	347,399	349,349	147,237
2005	1,135,551	327,222	333,846	327,969	146,514
2006	1,145,289	358,524	318,805	318,312	149,647

Notes:

^a Data source - Armed Forces Health Surveillance Center (AFHSC), Defense Medical Surveillance System (DMSS), 2007.

DOD - Department of Defense.

(2) The definition of injury adopted for this report was derived from one employed by the Department of Defense (DOD) Military Injury Metrics Work Group⁽¹⁵⁾ that states: injuries are nonfatal traumatic wounds or other conditions of the body caused by external force or exposure (that is, transfer of kinetic energy, heat, or cold) or nontraumatic physiological harm or loss of capacity caused by continued or repeated neuromusculoskeletal stress or strain. The definition includes both generally accepted International Classification of Disease (ICD-9-CM) codes from the 800–999 code series for acute injuries but also selected diagnoses from the 716-739 code series (such as, stress fractures, tendonitis, bursitis, and so forth) that are commonly accepted as injuries in the sports medicine literature⁽¹⁶⁻²⁰⁾ and the Armed Forces Health Surveillance Center

(AFHSC) Installation Injury Report.⁽²¹⁾ Only those visits for which injury was the primary diagnosis were included. The effect of follow-up visits was reduced by excluding diagnoses for the same condition for the same person if the same injury occurred more than once in a 60-day period of time.

(3) To determine the importance of injuries as a public health problem compared to other health conditions, a request was made to AFHSC for hospital and ambulatory/outpatient care data from the DMSS, broken down by the seventeen standard Principle Diagnosis Groups (PDGs) from the ICD-9-CM code book. The data for this part of the request was for the calendar year 2006 (1 January 2006 to 30 December 2006) for each of the Services and for the DOD overall including: (1) all medical encounters for each PDG, (2) the number of individuals with one or more of a particular diagnosis for each of the seventeen PDGs (visits for duplicate diagnoses excluded), and (3) the number of bed days in the hospital for a specific diagnosis in each of the seventeen PDGs.

(4) To document the general rates and trends of injury since 2000, overall injury frequencies, Service populations and rates were requested from the AFHSC for overall injuries (acute and chronic) and for lower extremity overuse (LEOU) injuries. In order to determine the types of injuries for which military personnel received medical care in the most recent complete year, 2006, a data request was made for both hospital and outpatient data broken out by diagnosis and location in form of the Barell Matrix.^(22, 23)

(5) To quantify injury-related musculoskeletal conditions, data on conditions in the ICD-9-CM code series 716 to 739 was requested in the form of a matrix for hospitalized and ambulatory (outpatient) conditions treated in 2006. The 60-day exclusion rule (described above) was applied to reduce duplicate entries due to follow-up. The method for creating the injury-related musculoskeletal injury category is more fully described in a later section dedicated to musculoskeletal injuries.

(6) A request was also made to the AFHSC for DMSS hospitalization data by cause of injury for the most recent complete year, 2006. This was done to determine what circumstances and events are associated with different types of acute injuries (ICD-9 codes 800 to 999). The North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 2050 cause codes⁽²⁴⁾ were employed for coding of hospitalization information on military personnel rather than ICD-9 E-codes since that is the only cause code data available for the Services. Injury causes of hospitalization received codes for intent (intentional versus unintentional), as well as three digits that provided more detail. General cause code categories included air transport, land transport, athletics, falls, machinery/tools, environmental factors, and instrumentalities of war. Unfortunately, military outpatient data were not cause coded at the time of this report.

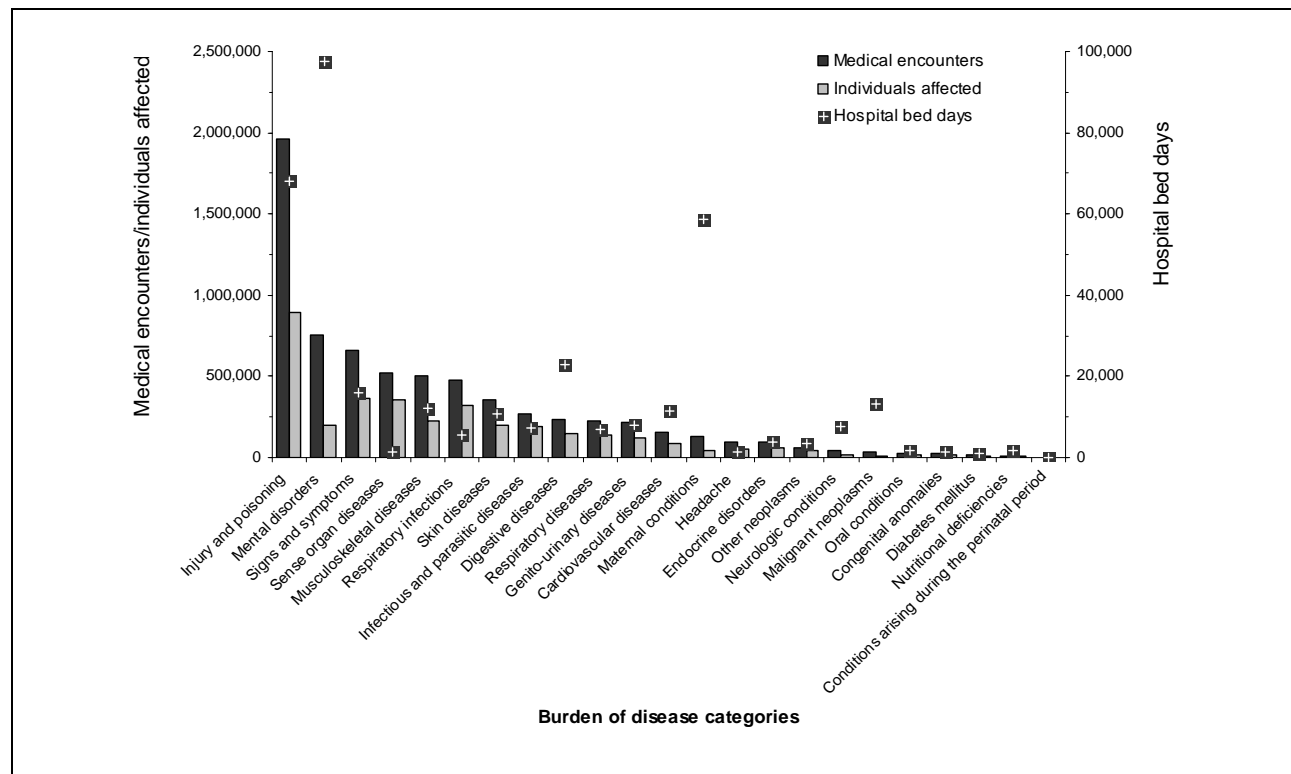
(7) Rates of injury were calculated using person-years in the denominator, based on personnel data for each Service (Table 3-1-1). In regard to the composition of the Active Duty

population, 85.4 percent were men and 14.6 percent were women. In addition, 83 percent of the men and 77 percent of the women were age 35 years of age and younger.

C. RESULTS.

(1) RELATIVE IMPORTANCE OF INJURIES.

(A) Figure 3-1-1 shows the relative importance of injuries versus other health conditions. The graph clearly indicates that injuries were the leading cause of medical encounters, with over 1.95 million in 2006. This is more than 2.5 times the next leading category, mental disorders, at just over 755,000 encounters. Almost a million individual Service members were affected by injuries. This is more than 2.5 times the number of personnel affected by the next leading PDG, sense organ disorders. The number of hospital bed days for injuries, 68,000 days in 2006, was superseded only by mental disorders, at almost 98,000 for the year. It should be noted in regard to bed days that most injuries, even those as serious as fractures, were treated on an outpatient basis.



Note:

^a Source: AFHSC, DMSS, 2007.

FIGURE 3-1-1. BURDEN OF INJURY VERSUS DISEASE, U.S. ARMED FORCES, 2006^a

(B) Table 3-1-2 displays the number of hospitalizations by PDG for DOD and the Services in 2006. Injuries (n = 11,591) were the leading cause of adverse health event hospitalization for DOD (pregnancies are not considered adverse health events). The same was true for Army and Marine Corps, but injuries were only the second leading cause of adverse health event hospitalization for the Air Force and the Navy. The rate of hospitalization for Service members with one or more injury, for DOD in 2006, was 1,012 injury hospitalizations per 100,000 personnel.

(C) Table 3-1-3 shows the number of outpatient-treated injuries by PDG for DOD and the Services. Over 1,000,000 injuries to Service members were treated in outpatient clinics. This was more than twice as many as for the next leading cause—respiratory diseases. The same is true for each of the Services. For DOD overall, the rate of injury clinic visits for service members with one or more injury of a particular type in 2006 was 999 outpatient injuries per 1,000.

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TABLE 3-1-2. HOSPITALIZATIONS BY PRINCIPLE DIAGNOSIS GROUP FOR ACTIVE DUTY MILITARY, DEPARTMENT OF DEFENSE, AND BY SERVICE, 2006^{a, b}

Category	ICD-9 codes	DOD			Army			Navy			Air Force			Marines		
		Injury ^c	Not injury	Total	Injury ^c	Not injury	Total	Injury ^c	Not injury	Total	Injury ^c	Not injury	Total	Injury ^c	Not injury	Total
Infectious/parasitic	001-139	0	1,197	1,197	0	602	602	0	223	223	0	243	243	0	129	129
Neoplasm	140-239	0	1,858	1,858	0	803	803	0	477	477	0	467	467	0	111	111
Endocrine	240-279	0	867	867	0	356	356	0	207	207	0	230	230	0	74	74
Blood	280-289	0	468	468	0	169	169	0	107	107	0	142	142	0	50	50
Mental	290-319	0	10,503	10,503	0	5,434	5,434	0	2,046	2,046	0	1,862	1,862	0	1,161	1,161
Nervous	320-389	45	1,036	1,081	25	464	489	8	202	210	6	237	243	6	133	139
Circulatory	390-459	0	2,494	2,494	0	1,091	1,091	0	527	527	0	678	678	0	198	198
Respiratory	460-519	0	2,668	2,668	0	1,424	1,424	0	370	370	0	461	461	0	413	413
Gastrointestinal	520-579	4	6,361	6,365	4	2,812	2,816	0	1,317	1,317	0	1,587	1,587	0	645	645
Genitourinary	580-629	0	2,543	2,543	0	1,154	1,154	0	497	497	0	726	726	0	166	166
Pregnancy	630-677	0	15,157	15,157	0	5,004	5,004	0	4,207	4,207	0	4,908	4,908	0	1,038	1,038
Skin	680-709	0	2,005	2,005	0	941	941	0	378	378	0	278	278	0	408	408
Musculoskeletal	710-739	3,532	2,718	6,250	1,854	1,420	3,274	528	478	1,006	709	528	1,237	441	292	733
Congenital anomalies	740-759	0	312	312	0	122	122	0	70	70	0	84	84	0	36	36
Perinatal	760-779	0	5	5	0	3	3	0	1	1	0	1	1	0	0	0
Symptoms Ill-defined	780-799	0	4,275	4,275	0	2,106	2,106	0	846	846	0	1,004	1,004	0	319	319
Injury/Poison	800-999	8,010	2,429	10,439	4,387	1,174	5,561	1,183	454	1,637	969	467	1,436	1,471	334	1,805
<i>Total^d</i>		11,591	56,896	68,487	6,270	25,079	31,349	1,719	12,407	14,126	1,684	13,903	15,587	1,918	5,507	7,425

Notes:

^a Source: AFHSC, DMSS, 2007.

^b Incident rule: visit is >60 days from preceding visit for the same dx (identified using 3-digit ICD-9 code).

^c As defined in AFHSC's Installation Injury Reports, primary diagnosis only; (http://afhsc.army.mil/InjuryReports/Online_documentation_20041022.pdf).

^d V and E codes removed from total.

TABLE 3-1-3. AMBULATORY VISITS BY PRINCIPLE DIAGNOSIS GROUP FOR ACTIVE DUTY MILITARY, DEPARTMENT OF DEFENSE, AND BY SERVICE, 2006^{a, b}

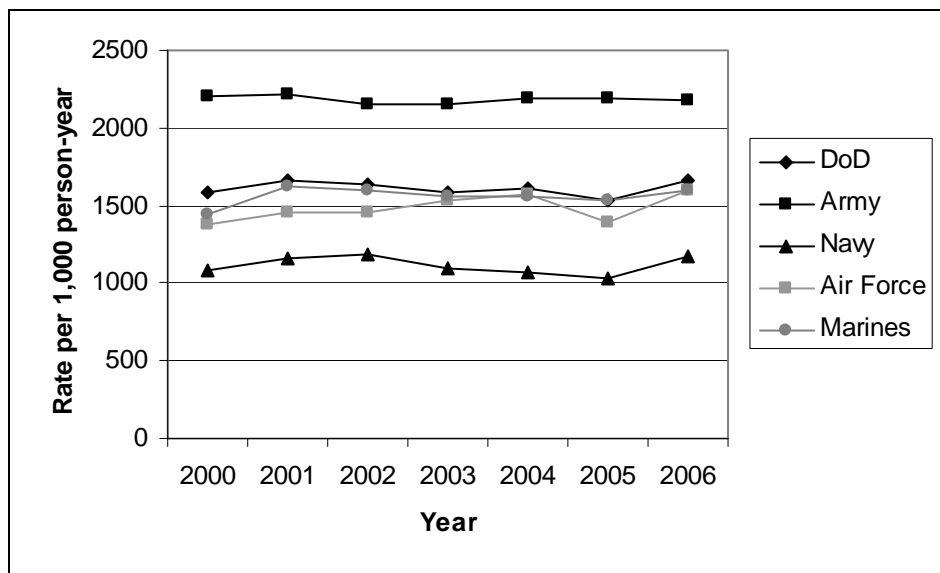
Category	ICD-9 codes	DOD			Army			Navy			Air Force			Marines		
		Injury ^c	Not injury	Total	Injury ^c	Not injury	Total	Injury ^c	Not injury	Total	Injury ^c	Not injury	Total	Injury ^c	Not injury	Total
Infectious/parasitic	001-139	0	193,385	193,385	0	68,973	68,973	0	52,341	52,341	0	48,633	48,633	0	23,438	23,438
Neoplasm	140-239	0	55,346	55,346	0	17,807	17,807	0	13,777	13,777	0	19,417	19,417	0	4,345	4,345
Endocrine	240-279	0	87,137	87,137	0	30,655	30,655	0	24,571	24,571	0	25,710	25,710	0	6,201	6,201
Blood	280-289	0	10,816	10,816	0	3,502	3,502	0	3,301	3,301	0	3,166	3,166	0	847	847
Mental	290-319	0	245,095	245,095	0	116,542	116,542	0	50,822	50,822	0	54,715	54,715	0	23,016	23,016
Nervous	320-389	13,344	492,853	506,197	4,338	177,962	182,300	3,795	118,212	122,007	4,135	142,140	146,275	1,076	54,539	55,615
Circulatory	390-459	0	102,929	102,929	0	36,761	36,761	0	25,924	25,924	0	33,178	33,178	0	7,066	7,066
Respiratory	460-519	0	508,782	508,782	0	186,057	186,057	0	104,984	104,984	0	160,329	160,329	0	57,412	57,412
Gastrointestinal	520-579	19	193,621	193,640	8	74,330	74,338	3	43,649	43,652	3	58,040	58,043	5	17,602	17,607
Genitourinary	580-629	0	167,720	167,720	0	63,504	63,504	0	37,877	37,877	0	53,669	53,669	0	12,670	12,670
Pregnancy	630-677	0	64,596	64,596	0	22,347	22,347	0	17,819	17,819	0	20,545	20,545	0	3,885	3,885
Skin	680-709	1,284	245,189	246,473	530	88,902	89,432	283	56,827	57,110	244	70,849	71,093	227	28,611	28,838
Musculoskeletal	710-739	589,828	276,789	866,617	259,004	115,834	374,838	104,394	54,913	159,307	168,022	78,003	246,025	58,408	28,039	86,447
Congenital anomalies	740-759	0	17,650	17,650	0	7,050	7,050	0	4,089	4,089	0	4,584	4,584	0	1,927	1,927
Perinatal	760-779	0	850	850	0	378	378	0	205	205	0	203	203	0	64	64
Symptoms Ill-defined	780-799	0	483,273	483,273	0	190,682	190,682	0	105,803	105,803	0	147,584	147,584	0	39,204	39,204
Injury/Poison	800-999	539,371	33,998	573,369	222,032	14,527	236,559	114,054	7,228	121,282	125,087	8,217	133,304	78,198	4,026	82,224
Total ^d		1,143,846	3,180,029	4,323,875	485,912	1,215,813	1,701,725	222,529	722,342	944,871	297,491	928,982	1,226,473	137,914	312,892	450,806

Notes:

^a Source: AFHSC, DMSS, 2007.^b Incident rule: visit is >60 days from preceding visit for the same dx (identified using 3-digit ICD-9 code).^c As defined in AFHSC's Installation Injury Reports, primary diagnosis only.^d V and E codes removed from total.

(2) INJURY RATES AND TRENDS FOR THE DOD AND THE SERVICES.

(A) Figure 3-1-2 shows overall rates and trends for all injury-related hospitalizations and outpatient visits combined in 2006—the overall DOD and the individual Services' injury rate. For the rates in Figure 3-1-2, a Service member could have more than one injury of the same or other type. The DOD rate was over 1,600 injury visits per 1,000 Service members per year. The Army showed the highest rates, almost 2,200 per 1,000 person years. Rates for the Services were fairly flat from 2000 to 2006.



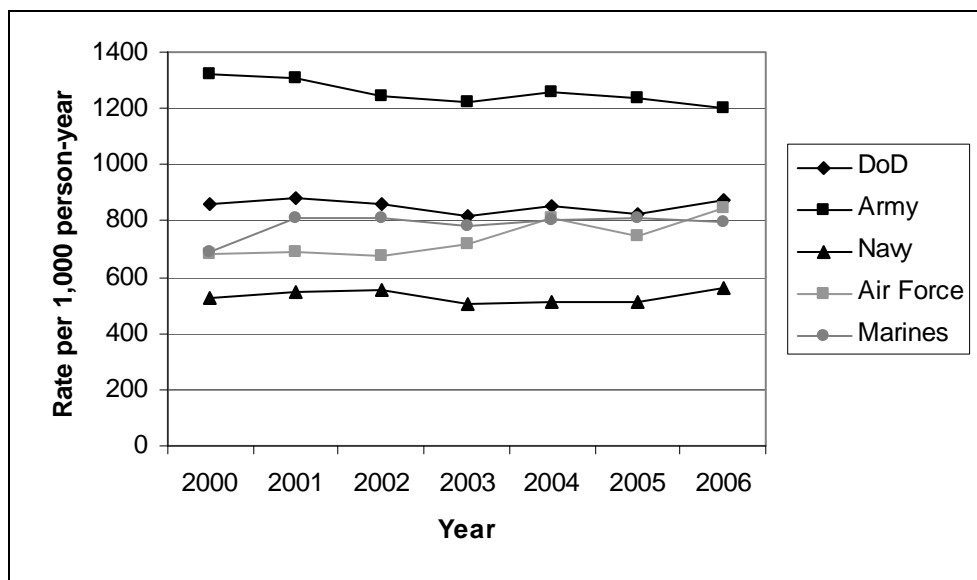
Notes:

^a Inpatient & outpatient visits; primary & non-primary diagnoses; considered a follow-up visit if same diagnoses seen within 60 days.

^b Source: AFHSC, DMSS, 2007.

FIGURE 3-1-2. OVERALL RATES OF INJURY, ACTIVE DUTY MILITARY, DEPARTMENT OF DEFENSE, AND BY SERVICE, 2000–2006^{a, b}

(B) Figure 3-1-3 displays rates for the most common general type of injury—LEOU injuries (for example, conditions such as stress fractures, Achilles tendonitis, plantar fasciitis, bursitis, and so forth) for DOD and the Services. The rate of DOD LEOU injury visits was almost 900 such injuries per 1,000 person-years. The LEOU injury rates were highest for the Army and lowest for the Navy. Rates of LEOU injuries have been decreasing for the Army and going up for the Air Force and the Marines. It should be kept in mind that on average half of the Navy is at sea at any given time and injuries on shipboard are not captured in the automated medical records system.



Notes:

^a Inpatient and outpatient visits; primary and non-primary diagnoses; considered a follow-up visit if same diagnoses seen within 60 days.

^b Source: AFHSC, DMSS, 2007.

FIGURE 3-1-3. LOWER EXTREMITY OVERUSE INJURY RATES, ACTIVE DUTY MILITARY, DEPARTMENT OF DEFENSE, AND BY SERVICE, 2000–2006^{a, b}

(3) TYPES (DIAGNOSES) AND LOCATIONS OF ACUTE TRAUMATIC INJURIES.

(A) Table 3-1-4 displays types of injuries (such as, fractures, sprains and strains, and so forth) resulting in hospitalization by body location (Barell Matrix format) for the DOD. These acute, mostly traumatic, injuries caused almost 7,000 hospitalizations in 2006. The most common type of injury hospitalized in 2006 was fractures, accounting for 39.6 percent of the total. After fractures, in order, internal injuries (12 percent), open wounds (9 percent), and sprains and strains (8 percent) were the next most common. The leading location of hospitalized traumatic injuries was the lower extremity, with a combined total of 28 percent of injuries. The second leading location of hospitalized injuries was the upper extremity at 19.1 percent. Just over 9 percent (9.2 percent) of injury hospitalizations were due to traumatic brain injuries (TBI).

(B) Table 3-1-5 presents data on the types of injuries by body location (Barell Matrix format) for ambulatory/outpatient injuries—a total of over 540,000 injuries. The leading types of injuries were sprains and strains, accounting for 48.8 percent of total outpatient injuries. Contusions followed at 16 percent, then fractures (10 percent), and open wounds (8 percent). There were over 7,000 TBIs treated in outpatient settings.

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TABLE 3-1-4. FREQUENCY OF INJURY HOSPITALIZATIONS BY MAJOR ICD-9 INJURY CODE AND BODY LOCATION
(BARELL MATRIX), ACTIVE DUTY MILITARY, 2006^{a, b}

Injury Location																	System- wide & late effects	Total	%Total
			Fracture	Dislocation	Sprains/ Strains	Internal	Open Wound	Amputations	Blood Vessel	Contusion/ Superficial	Crush	Burns	Nerves	Unspecified					
Head and Neck	Traumatic Brain Injury (TBI)	Type 1 TBI	117	0	0	246	0	0	0	0	0	0	0	0	0	0	363	5.2%	
		Type 2 TBI	49	0	0	212	0	0	0	0	0	0	0	0	0	0	261	3.8%	
		Type 3 TBI	11	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0.2%	
	Other Head, Face, Neck	Other head	0	0	0	0	46	0	0	0	0	0	0	69	0	115	1.7%		
		Face	357	1	0	0	61	0	0	0	0	11	0	0	0	430	6.2%		
		Eye	0	0	0	0	36	0	0	27	0	2	0	0	0	65	0.9%		
		Neck	2	0	0	0	8	0	0	0	1	4	1	0	0	16	0.2%		
		Head, Face, Neck Unspec.	0	0	0	0	0	0	5	48	1	27	0	8	0	89	1.3%		
Spine and Back	Spinal Cord (SCI)	Cervical SCI	18	0	0	18	0	0	0	0	0	0	0	0	0	36	0.5%		
		Thoracic/Dorsal SCI	21	0	0	3	0	0	0	0	0	0	0	0	0	24	0.3%		
		Lumbar SCI	7	0	0	1	0	0	0	0	0	0	0	0	0	8	0.1%		
		Sacrum Coccyx SCI	0	0	0	3	0	0	0	0	0	0	0	0	0	3	0.0%		
		Spine, Back Unspec. SCI	0	0	0	15	0	0	0	0	0	0	0	0	0	15	0.2%		
		Cervical VCI	50	8	22	0	0	0	0	0	0	0	0	0	0	80	1.2%		
	Vertebral Column (VCI)	Thoracic/Dorsal VCI	52	0	3	0	0	0	0	0	0	0	0	0	0	55	0.8%		
		Lumbar VCI	89	4	13	0	0	0	0	0	0	0	0	0	0	106	1.5%		
		Sacrum Coccyx VCI	18	1	0	0	0	0	0	0	0	0	0	0	0	19	0.3%		
		Spine, Back Unspec. VCI	4	0	0	0	0	0	0	0	0	0	0	0	0	4	0.1%		
Torso	Torso	Chest (thorax)	66	0	1	167	18	0	4	14	0	2	0	0	0	272	3.9%		
		Abdomen	0	0	0	167	19	0	1	7	0	2	0	0	0	196	2.8%		
		Pelvis, Urogenital	86	2	1	12	19	0	2	10	2	0	0	0	0	134	1.9%		
		Trunk	3	0	0	0	3	0	0	15	0	3	0	5	0	29	0.4%		
		Back, Buttock	0	0	3	0	6	0	0	10	0	6	0	0	0	25	0.4%		
Extremities	Upper	Shoulder, Upper Arm	182	56	124	0	19	2	0	9	1	4	0	13	0	410	5.9%		
		Forearm, Elbow	216	6	2	0	49	0	0	3	4	12	0	0	0	292	4.2%		
		Wrist, Hand, Fingers	249	19	13	0	184	27	0	11	8	20	0	12	0	543	7.8%		
		Other & Unspec.	7	0	0	0	10	0	7	12	0	8	37	4	0	85	1.2%		
		Hip	57	8	4	0	0	0	0	5	0	0	0	0	0	74	1.1%		
	Lower	Upper leg, Thigh	120	0	0	0	0	3	0	5	0	6	0	0	0	134	1.9%		
		Knee	34	112	235	0	0	0	0	1	0	0	0	0	0	382	5.5%		
		Lower leg, Ankle	768	15	82	0	0	4	0	11	1	10	0	0	0	891	12.8%		
		Foot, toes	141	8	3	0	32	2	0	12	3	7	0	0	0	208	3.0%		
		Other & Unspec.	12	0	61	0	110	0	3	28	0	6	0	36	0	256	3.7%		
Unclass. by Site	Other, Unspecified	Other/Multiple	7	0	0	0	0	0	1	0	0	0	9	0	0	17	0.2%		
		Unspec. Site	8	0	15	10	15	0	0	41	1	18	8	75	0	191	2.8%		
	System-wide & late effects		0	0	0	0	0	0	0	0	0	0	0	0	1,103	1,103	15.9%		
Total			2,751	240	582	854	635	38	23	269	22	148	55	222	1,103	6,942			
% Total			39.6%	3.5%	8.4%	12.3%	9.1%	0.5%	0.3%	3.9%	0.3%	2.1%	0.8%	3.2%	15.9%				

Note:

^a Source: AFHSC, as of 31 Dec 07.

^b Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9 code).

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TABLE 3-1-5. FREQUENCY OF INJURY AMBULATORY VISITS BY MAJOR ICD-9 INJURY CODE AND BODY LOCATION
(BARELL MATRIX), ACTIVE DUTY MILITARY, 2006

Injury Location			Injury Type												System-wide & late effects	Total	%Total
			Fracture	Dislocation	Sprains/ Strains	Internal	Open Wound	Amputations	Blood Vessel	Contusion/ Superficial	Crush	Burns	Nerves	Unspecified			
Head and Neck	Traumatic Brain Injury (TBI)	Type 1 TBI	225	0	0	2,055	0	0	0	0	0	0	5	0	0	2,285	0.4%
		Type 2 TBI	366	0	0	4,476	0	0	0	0	0	0	0	0	0	4,842	0.9%
		Type 3 TBI	77	0	0	0	0	0	0	0	0	0	0	0	0	77	0.0%
	Other Head, Face, Neck	Other head	0	0	0	0	3,699	0	0	0	0	21	55	5,367	0	9,142	1.7%
		Face	3,420	72	226	0	8,970	0	0	0	0	126	0	0	0	12,814	2.4%
		Eye	0	0	0	0	960	0	0	10,974	0	378	44	0	0	12,356	2.3%
		Neck	5	0	2	0	160	0	0	0	16	100	43	0	0	326	0.1%
		Head, Face, Neck Unspec.	0	0	0	0	0	0	88	6,963	28	304	14	2,536	0	9,933	1.8%
Spine and Back	Spinal Cord (SCI)	Cervical SCI	75	0	0	175	0	0	0	0	0	0	0	0	0	250	0.0%
		Thoracic/Dorsal SCI	291	0	0	26	0	0	0	0	0	0	0	0	0	317	0.1%
		Lumbar SCI	53	0	0	48	0	0	0	0	0	0	0	0	0	101	0.0%
		Sacrum Coccyx SCI	7	0	0	11	0	0	0	0	0	0	0	0	0	18	0.0%
		Spine, Back Unspec. SCI	10	0	0	111	0	0	0	0	0	0	0	0	0	121	0.0%
	Vertebral Column (VCI)	Cervical VCI	361	129	15,191	0	0	0	0	0	0	0	0	0	0	15,681	2.9%
		Thoracic/Dorsal VCI	335	268	6,357	0	0	0	0	0	0	0	0	0	0	6,960	1.3%
		Lumbar VCI	609	106	19,738	0	0	0	0	0	0	0	0	0	0	20,453	3.8%
		Sacrum Coccyx VCI	223	60	622	0	0	0	0	0	0	0	0	0	0	905	0.2%
		Spine, Back Unspec. VCI	110	5	0	0	0	0	0	0	0	0	0	0	0	115	0.0%
Torso	Torso	Chest (thorax)	1,267	30	2,823	601	212	0	23	3,586	0	67	9	0	0	8,618	1.6%
		Abdomen	0	0	0	564	346	0	15	532	0	56	44	0	0	1,557	0.3%
		Pelvis, Urogenital	658	44	13,554	79	678	0	7	384	47	26	6	0	0	15,483	2.8%
		Trunk	11	0	0	0	99	0	0	1,864	3	64	7	2,908	0	4,956	0.9%
		Back, Buttock	0	0	9,061	0	236	0	0	1,537	10	69	0	0	0	10,913	2.0%
		Shoulder, Upper Arm	2,830	6,351	25,375	0	499	32	0	2,703	20	88	0	1,904	0	39,802	7.3%
Extremities	Upper	Forearm, Elbow	3,926	294	2,300	0	1,788	40	0	2,042	41	402	0	0	0	10,833	2.0%
		Wrist, Hand, Fingers	16,934	1,696	17,395	0	16,155	314	0	12,385	952	1,258	0	3,790	0	70,879	13.0%
		Other & Unspec.	134	0	0	0	605	13	67	2,114	10	170	1,148	1,447	0	5,708	1.1%
		Hip	574	170	11,458	0	0	0	0	908	5	0	0	0	0	13,115	2.4%
	Lower	Upper leg, Thigh	864	0	0	0	0	105	0	626	8	74	0	0	0	1,677	0.3%
		Knee	458	12,394	11,634	0	0	0	0	4,773	43	20	0	0	0	29,322	5.4%
		Lower leg, Ankle	8,914	235	54,060	0	0	163	0	2,299	69	159	0	0	0	65,899	12.1%
		Foot, toes	9,161	339	8,717	0	2,979	38	0	12,301	312	182	0	0	0	34,029	6.3%
		Other & Unspec.	473	0	46,246	0	3,788	95	74	4,773	11	163	0	8,532	0	64,155	11.8%
		Other/Multiple	48	0	0	0	0	0	1	0	0	12	397	0	0	458	0.1%
Unclass. by Site	Unspec. Site	956	162	20,356	184	3,146	0	17	18,007	100	1,260	323	1,939	0	46,450	8.5%	
	System-wide & late effects		0	0	0	0	0	0	0	0	0	0	0	0	23,033	23,033	4.2%
Total			53,375	22,355	265,115	8,330	44,320	800	292	88,771	1,675	4,999	2,095	28,423	23,033	543,583	
% Total			9.8%	4.1%	48.8%	1.5%	8.2%	0.1%	0.1%	16.3%	0.3%	0.9%	0.4%	5.2%	4.2%		

Notes:

^a Source: AFHSC, as of 31 Dec 07.

^b Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9 code).

(4) TYPES AND LOCATIONS OF OVERUSE AND CHRONIC INJURIES.

(A) Table 3-1-6 identifies the general types of injury-related musculoskeletal conditions that result in hospitalization. This table is arranged in the same manner as the Barell Matrix, with injury types on the horizontal axis and body location on the vertical axis.⁽²⁴⁾ These types of injuries resulted in just over 3,300 hospitalizations of Active Duty Service members in 2006. The most common conditions were categorized as “other derangements of joints”, accounting for 47.3 percent of hospitalizations. The second leading category of injury-related musculoskeletal conditions was the category of “pain and inflammation,” which includes conditions commonly seen in civilian orthopedic and sports medicine clinics, such as Achilles tendonitis, plantar fasciitis, bursitis and patello-femoral syndrome. These painful, sometimes disabling overuse inflammatory conditions, account for 24.9 percent of the total. The most common region of the body suffering this type of injury is the back and spine. Back complaints and injuries constituted 43.2 percent of the total injury-related musculoskeletal conditions that required hospitalization.

(B) Table 3-1-7 shows the types of injury-related musculoskeletal conditions by body location (Barell Matrix-like format) that resulted in treatment in outpatient clinics. Over 535,000 injury-related musculoskeletal conditions to Active Duty Service members were treated in outpatient clinics in 2006. “Pain and inflammation” were the most common type of injuries, at 84.0 percent of the total. The most commonly injured body region was the lower extremity, accounting for 48.8 percent of the total.

TABLE 3-1-6. FREQUENCY OF INJURY-RELATED MUSCULOSKELETAL CONDITIONS FOR HOSPITALIZATIONS (MATRIX BY INJURY TYPE AND BODY LOCATION), ACTIVE DUTY MILITARY, 2006^{a, b}

Injury Location			Inflammation/Pain ^c (Overuse)	Inflammation/Pain with Nerves ^c (Overuse)	Stress Fracture	Sprains/Strains/ Rupture	Dislocation	Other Joint Derangement ^c	Total	% Total
Spine and Back	Vertebral Column (VCI)	Cervical VCI	30	59	0	0	0	250	339	10.2%
		Thoracic/Dorsal VCI	0	37	0	0	0	8	45	1.4%
		Lumbar VCI	135	37	0	0	0	826	998	30.0%
		Sacrum Coccyx VCI	1	0	0	0	0	0	1	0.0%
		Spine, Back Unspec. VCI	3	3	5	0	0	41	52	1.6%
Extremities	Upper	Shoulder	218	0	0	16	60	157	451	13.5%
		Upper arm, Elbow	39	0	0	0	1	3	43	1.3%
		Forearm, Wrist	11	0	0	0	1	11	23	0.7%
		Hand	4	0	0	4	0	7	15	0.5%
	Lower	Pelvis, Hip, Thigh	22	0	6	2	1	19	50	1.5%
		Lower leg, Knee	200	0	15	530	29	160	934	28.0%
		Ankle, Foot	92	0	0	3	13	80	188	5.6%
Unclass. by Site	Others and Unspecified	Other specified/Multiple	13	0	1	1	1	10	26	0.8%
		Unspec. Site	63	15	81	2	0	5	166	5.0%
Total			831	151	108	558	106	1,577	3,331	
% Total			24.9%	4.5%	3.2%	16.8%	3.2%	47.3%		

Notes:

^a Source: AFHCS, as of 31 Dec 07.^b Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9 code).^c Examples of pain/inflammation musculoskeletal conditions include tendonitis, bursitis, and lumbago. Examples of pain/inflammation with nerve involvement include sciatica and thoracic/lumbosacral neuritis and radiculitis. Examples of other joint derangements include intervertebral disc disorders, meniscus tear, and joint instability.

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TABLE 3-1-7. FREQUENCY OF INJURY-RELATED MUSCULOSKELETAL CONDITIONS FOR AMBULATORY VISITS (MATRIX BY INJURY TYPE AND BODY LOCATION), ACTIVE DUTY MILITARY, 2006^{a, b}

Injury Location			Inflammation/Pain ^c (Overuse)	Inflammation/Pain with Nerves ^c (Overuse)	Stress Fracture	Sprains/Strains/ Rupture	Dislocation	Other Joint Derangement ^c	Total	% Total
Spine and Back	Vertebral Column (VCI)	Cervical VCI	24,671	4,249	0	0	0	3,208	32,128	6.0%
		Thoracic/Dorsal VCI	0	5,698	0	0	0	338	6,036	1.1%
		Lumbar VCI	78,750	6,120	0	0	0	10,955	95,825	17.8%
		Sacrum Coccyx VCI	3,216	0	0	0	0	0	3,216	0.6%
		Spine, Back Unspec. VCI	20	1,303	177	0	0	3,423	4,923	0.9%
Extremities	Upper	Shoulder	57,416	0	0	1,990	1,641	4,756	65,803	12.3%
		Upper arm, Elbow	12,535	0	11	0	20	195	12,761	2.4%
		Forearm, Wrist	11,815	0	22	0	14	505	12,356	2.3%
		Hand	6,820	0	0	502	41	206	7,569	1.4%
	Lower	Pelvis, Hip, Thigh	19,016	0	106	192	12	283	19,609	3.7%
		Lower leg, Knee	124,648	0	5,449	8,017	358	12,989	151,461	28.2%
		Ankle, Foot	86,119	0	0	240	114	4,545	91,018	16.9%
Unclass . by Site	Others and Unspecified	Other specified/Multiple	3,019	0	271	55	9	147	3,501	0.7%
		Unspec. Site	23,113	2,585	4,754	303	11	183	30,949	5.8%
Total			451,158	19,955	10,790	11,299	2,220	41,733	537,155	
% Total			84.0%	3.7%	2.0%	2.1%	0.4%	7.8%		

Notes:

^a Source: AFHSC, as of 31 Dec 07.

^b Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9 code).

^c Examples of pain/inflammation musculoskeletal conditions include tendonitis, bursitis, and lumbago. Examples of pain/inflammation with nerve involvement include sciatica and thoracic/lumbosacral neuritis and radiculitis. Examples of other joint derangements include intervertebral disc disorders, meniscus tear, and joint instability.

(5) CAUSES OF INJURY-RELATED HOSPITALIZATIONS.

(A) Table 3-1-8 shows the frequencies, rates, and percent distribution of the leading causes of injuries resulting in hospitalizations of DOD military personnel for the total DOD and for each of the Services. The “Falls and Miscellaneous” category accounted for 34.3 percent of all hospitalizations in DOD in 2006. Within this category, falls/jumps and near-falls (slips and trips) accounted for the largest portion—17.5 percent of all injury hospitalizations. The second leading cause was “Accidents of Land Transport,” which resulted in 19.1 percent of all injury hospitalizations.

(B) Nonmilitary privately owned motor vehicle (MV) mishaps were the leading type of vehicle associated with injury hospitalizations, accounting for 15.4 percent of all injuries. Athletic and sports injuries comprised the third leading category of hospitalization for injury, 13.1 percent of all hospitalized injuries. Intentional, nonbattle injuries (such as, fight and assault-related injuries) were the fifth leading cause of hospitalized injuries, resulting in 8.0 percent of the total for DOD. Parachute jump-related injuries accounted for 4.7 percent of all hospitalizations in DOD. However, the vast majority of parachute injuries occurred among Army personnel.

TABLE 3-1-8. HOSPITALIZED NONBATTLE CAUSES OF INJURY FOR ACTIVE DUTY MILITARY, DEPARTMENT OF DEFENSE, AND BY SERVICE, 2006

Category	DoD			Army			Navy			Air Force			Marines		
	Frequency	Rate ^c	% of total	Frequency	Rate ^c	% of total	Frequency	Rate ^c	% of total	Frequency	Rate ^c	% of total	Frequency	Rate ^c	% of total
Falls, misc. other unspec.^d	1,483	129.5	34.3	895	249.6	36.5	194	60.9	29.2	181	56.9	30.3	213	142.3	35.1
<i>Fall/jump (stairs, same/diff level)</i>	578	50.5	13.4	285	79.5	11.6	102	32.0	15.3	91	28.6	15.2	100	66.8	16.5
<i>Twist, turn, slip (no fall)</i>	178	15.5	4.1	111	31.0	4.5	21	6.6	3.2	21	6.6	3.5	25	16.7	4.1
<i>Misc. other, unspec</i>	727	63.5	16.8	499	139.2	20.3	71	22.3	10.7	69	21.7	11.6	88	58.8	14.5
Accidents-Land Transport	824	71.9	19.1	383	106.8	15.6	181	56.8	27.2	174	54.7	29.1	86	57.5	14.2
<i>Non-military Vehicle</i>	666	58.2	15.4	305	85.1	12.4	153	48.0	23.0	139	43.7	23.3	69	46.1	11.4
<i>Military Vehicle</i>	50	4.4	1.2	23	6.4	0.9	5	1.6	0.8	13	4.1	2.2	9	6.0	1.5
<i>Non-traffic and other land transport</i>	108	9.4	2.5	55	15.3	2.2	23	7.2	3.5	22	6.9	3.7	8	5.3	1.3
Athletics & Sports	567	49.5	13.1	280	78.1	11.4	100	31.4	15.0	99	31.1	16.6	88	58.8	14.5
Complications-Medical	348	30.4	8.0	206	57.5	8.4	38	11.9	5.7	24	7.5	4.0	24	16.0	4.0
Intentional Injuries, non-battle	222	19.4	5.1	136	37.9	5.5	46	14.4	6.9	33	10.4	5.5	63	42.1	10.4
Machinery, tools	221	19.3	5.1	122	34.0	5.0	28	8.8	4.2	30	9.4	5.0	41	27.4	6.8
Accidents-Air Transport	220	19.2	5.1	197	54.9	8.0	6	1.9	0.9	12	3.8	2.0	5	3.3	0.8
<i>Parachute</i>	202	17.6	4.7	189	52.7	7.7	3	0.9	0.5	8	2.5	1.3	2	1.3	0.3
<i>Military aircraft, air transport other</i>	18	1.6	0.4	8	2.2	0.3	3	0.9	0.5	4	1.3	0.7	3	2.0	0.5
Environmental Factors	202	17.6	4.7	115	32.1	4.7	22	6.9	3.3	14	4.4	2.3	51	34.1	8.4
Guns, explosives	90	7.9	2.1	61	17.0	2.5	8	2.5	1.2	13	4.1	2.2	8	5.3	1.3
Poisons, fire, hot/corrosive substances	64	5.6	1.5	36	10.0	1.5	11	3.5	1.7	11	3.5	1.8	6	4.0	1.0
Instrumentalities of War-Enemy	42	3.7	1.01	12	3.3	0.51	9	2.8	1.4	3	0.9	0.5	18	12.0	3.0
Accidents-Water Transport	38	3.3	0.92	11	3.1	0.47	22	6.9	3.3	3	0.9	0.5	2	1.3	0.3
Instrumentalities of War-Self, Accidents	2	0.2	0.05	0	0	0	0	0.0	0.0	0	0.0	0.0	2	1.3	0.3
Total^e	4,323	377.5	100	2,454	684.3	100	665	208.6	100	597	187.6	100	607	405.6	100

Notes:

^a Source: AFHSC, DMSS, 2007.^b Population: DOD=1,145,289; Army=385,524; Navy=318,805; Air Force=318,312; Marines=149,647.^c Rate per 100,000 person-years. In descending order by DOD rate.^d Fighting excluded from falls and miscellaneous and added to intentional injuries.^e Missing STANAG codes (not included in total): DOD=5,171; Army=2,344; Navy=952; Air Force=597; Marines=607.

D. DISCUSSION

(1) SUMMARY OF CURRENT MEDICAL SURVEILLANCE DATA.

(A) In 2006, a total of 764 Service members died from nonbattle injuries.⁽²⁵⁾ However, this number was small compared to the roughly 1,000,000 Services members who suffered nonfatal, nonbattle injuries. When looking at hospitalizations, injuries accounted for 16.9 percent (n = 11,591) of all hospitalizations. The next highest reason for hospitalization was mental disorders at 15.3 percent (n = 10,503), followed by gastrointestinal diseases at 9.3 percent (n = 6,361). Looking at conditions treated in outpatient clinics, we also saw that injuries were the leading health problem requiring outpatient medical care, at 26.5 percent of all such visits (n = 1,143,846). The next leading cause of outpatient visits was respiratory illness at 11.8 percent (n = 508,782) and the third, neurological conditions at 11.4 percent (n = 492,853).

(B) For every death due to a traumatic injury in 2006, there were 11 hospitalizations and 715 injuries treated in outpatient settings (Figure 3-1-4). When ratios for deaths due to all injuries—acute and overuse/chronic in nature—were calculated, there were 16 hospitalizations and over 1,500 outpatient visits for every death (Figure 3-1-4). As also seen in the general U.S. population,⁽²⁶⁾ nonfatal injuries are by far the biggest health problem of the military. Attention must be focused on these nonfatal injuries to reduce the impact of injuries on the health and readiness of U.S. military personnel.

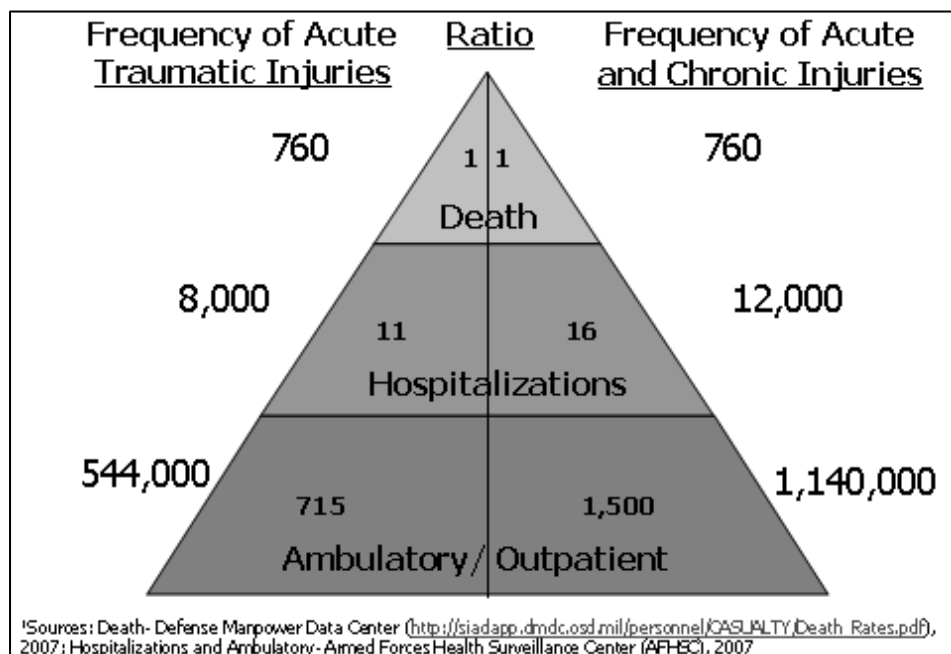


FIGURE 3-1-4. INJURY PYRAMID, ACTIVE DUTY MILITARY, 2006⁽¹⁾

(C) The most serious injuries for which military medical surveillance data are routinely available are those requiring hospitalization. As seen in Table 3-1-4, the most common type of acute traumatic injuries is fractures, accounting for almost 40 percent of all hospitalized injuries. From the perspective of hospitalizations, prevention of fractures must be a top priority. Traumatic brain injury, which tally about 9 percent of hospitalized injuries, are of concern because of their potential long-term disabling effects.

(D) Examination of injuries occurring in outpatient settings reveals a different order of priorities. Sprains and strains caused 49 percent of outpatient visits, more than 265,000 injuries treated (Table 3-1-5). Based on these numbers, sprains and strains must be another top priority for prevention. Fractures were the third leading category at 9.8 percent. This is impressive, as there were over 53,000 fractures treated on an outpatient basis, indicating how serious outpatient injuries can be. Although TBI accounted for less than 1.5 percent of outpatient injuries, they numbered more than 7,000; an obvious cause for concern.

(E) When looking at injury-related musculoskeletal conditions (Table 3-1-6), joint derangements accounted for 47 percent of all overuse/chronic injury hospitalizations, a cause for concern. The biggest overuse/chronic injury problems seen in ambulatory care (Table 3-1-7) are conditions that cause pain and inflammation, including Achilles tendonitis, plantar fasciitis, bursitis, and patello-femoral syndrome.

(F) For each level of severity (hospitalization or ambulatory/outpatient care) and each category of injury (acute or overuse/chronic), a different set of injury prevention priorities could be derived. Ruscio et al.,⁽¹⁰⁾ solved this problem by estimating numbers of limited duty days for each type of injury seen in the Barell and injury-related musculoskeletal matrices. Across the entire DOD, it was estimated that acute and overuse/chronic injuries together resulted in over 25,000,000 days of limited duty in 2005.⁽¹⁰⁾ The leading cause of acute traumatic injuries was fractures of the upper and lower extremities, which led to more than 5,000,000 days of limited duty. That was followed by lower extremity sprains and strains, at more than 1,800,000 days of limited duty. Among the injury-related musculoskeletal conditions, overuse injuries (such as, pain and inflammation) of the lower extremity resulted in an estimated 3,800,000 million days of limited duty. Based on the amount of morbidity in terms of limited duty days, priority for prevention (by injury type) would be given to fractures of the extremities, LEOU injuries, and lower extremity sprains and strains. The leading causes of the top five injury diagnosis groups resulting in limited duty days were found to be falls; sports and physical training; handling of guns and explosives; private vehicle mishaps; and slips, trips, and twists.⁽¹⁰⁾

(G) Cause of injury data presented in this paper showed that the leading causes of acute traumatic injury hospitalizations for military personnel are falls, MV mishaps, and athletics/sports (Table 3-1-7). For the military, these causes of injuries should be given top priority: (1) for prevention, where evidence of effective interventions exist, and (2) for research, where evidence of preventability is lacking.

(2) COMPARISONS OF U.S. AND MILITARY RATES.

(A) To get a relative sense of how big the problem of injuries is for the military, one can compare the rates of injuries among Service members with other populations. The most convenient comparisons can be made with U.S. and various state data. Military hospitalization rates for injury are not directly comparable to U.S. rates because the population of the Services is predominantly men under the age of 30 years. Nevertheless, such a comparison should provide a conservative impression of how high or low military rates of injury are. In their book, *The Incidence and Economic Burden of Injuries in the United States*, Finkelstein et al. break down the types and causes of injuries.⁽²⁷⁾ The manner in which it is done is similar to the way in which military data were tabulated for this paper. For that reason, the 2006 rates of hospitalization for the military are compared to those for the United States (2000) from Finkelstein's book. We felt this was a reasonable comparison, since military injury rates have been relatively stable from 2000 to 2006 (Figure 3-1-2). Another set of data used for comparisons comes from the State Injury Indicators Report.⁽²⁸⁾

(B) Overall rates of injury within the Services (including both acute traumatic conditions and injury-related musculoskeletal conditions) are a little over 1,000 hospitalizations per 100,000 Service members. However, if just the acute traumatic injury rate for the military is compared with the United States overall, the rates are 584 per 100,000 for the military (late effects and medical-surgical misadventures not included) and 676 per 100,000 for the United States.⁽²⁷⁾ Even though the military population is composed of some of the highest risk age groups, the rate is about the same as that for the United States. A 2004 survey of 34 states found that overall injury hospitalization rates for 15 to 24 year olds ranged from 232 per 100,000 (Rhode Island) to 650 per 100,000 (Arizona).⁽²⁸⁾ This same survey found that the 25 to 34 years old rates ranged from a low of 208 per 100,000 (Nebraska) to a high of 545 per 100,000 (Pennsylvania). The 2006 rate of acute traumatic injuries for U.S. military personnel (584 per 100,000) is at the high end of the states' rates for these age groups. Considering the vigorous nature of military training, this is a favorable comparison.

(C) If we examine some specific types of injuries from the Barell Matrix, we see a similar pattern for the military compared to the United States. The TBI hospitalization rates for the Services are about 55 per 100,000 Service members per year compared to 57 for the United States.⁽²⁷⁾ The TBI hospitalization rates in 2004 for the age group 15 to 24 years, reported by 34 states, ranged from a low of 33 per 100,000 (Rhode Island) to a high of 178 per 100,000 (Arizona).⁽²⁸⁾ For 25 to 35 year olds in the same 34 state survey, rates of TBI ranged from a low of 24 per 100,000 (Rhode Island) to a high of 109 (Pennsylvania). The rate for the U.S. military (55/100,000) is at the low end of this range. In examining another type of injury—fractures—a similar contrast with the United States as a whole is found. For the military, fractures result in hospitalizations for Service members at a rate of roughly 240 per 100,000 Service members per year while for the United States it is 333 per 100,000 population per year.⁽²⁷⁾ These comparisons of the military with the U.S. civilian population are extremely crude. Nevertheless, they suggest

that rates of injury hospitalization among Service members are not too high, relative to the United States as a whole or to similar age groups for a spectrum of states.

(D) In addition to the fact that hospitalization rates for military and civilian populations are similar, it is noteworthy that injury fatality rates are also similar. The crude rate of unintentional (“accidental”) injury deaths overall for the Services was 32.2 per 100,000 Service members in 2006.⁽²⁵⁾ The crude rate of unintentional injury deaths for the United States the year before (2005) was 39.7 per 100,000.⁽²⁹⁾ More specifically, the U.S. rate among 15 to 24 year olds was 37.4, while that for 25 to 34 year olds was 34.9.⁽²⁸⁾ These age categories for the United States correspond to the age distribution of Active Duty military personnel, of whom over 75 percent are under the age of 35.⁽²⁶⁾

(E) Crude suicide rates for the military overall were 11.7 per 100,000 per year, and those for homicides are 2.6.⁽²⁵⁾ For the U.S. population as a whole, these rates for suicides and homicides, respectively, are 11.0 and 6.1 per 100,000 in 2005.⁽²⁹⁾ For the 15 to 24 year olds in the United States, the unadjusted suicide and homicide rates were 10.0 and 13.0 per 100,000, respectively; for 25 to 34 year olds, 12.4 and 11.8 per 100,000, suicides and homicides, respectively.⁽²⁹⁾ Even though the comparisons are crude, these data suggest, as has been shown in the past,⁽³⁰⁾ that suicide rates for the military are not unduly high compared rates for the U.S. population in general. On the other hand, homicide rates appear to be lower in the military.

(F) In addition to hospitalization data, it is also recommended that other nonfatal injury data be utilized for surveillance. The most commonly recommended nonhospitalized medical data source is emergency department (ED) data.^(6, 11, 13, 31, 32) Several national surveys and national hospital samples report these data.⁽³³⁻³⁷⁾ A number of states have surveillance systems for nonfatal injuries that track hospitalizations and ED visits but do not track *all* outpatient care, as is done for Active Duty military in the DMSS. When he published his article in 2003, Horan noted that only 17 states had developed ED surveillance systems, and none were reported to have the ability to conduct surveillance of all outpatient injuries.⁽⁶⁾ As a result, direct comparisons of military outpatient data to most national or state data is not possible at this time.

(G) Crude comparisons are possible with U.S. data presented by Finkelstein et al.⁽²⁷⁾ Unlike hospitalization rates, comparison of rates of injuries for outpatient visits between Services and the United States as a whole indicates that rates for the military are higher. Overall, outpatient injury rates for the military were about 46,000 per 100,000 Service members per year, while for the United States, reported rates were 17,000 per 100,000 per year.⁽²⁷⁾ This equates to a rate 2.7 times higher for the military than for the United States. Comparing TBI rates, the rate for the military as calculated using data from this analysis was 606 per 100,000, while for the United States, it was 415 per 100,000 per year.⁽²⁷⁾ For fractures, the outpatient rates among military personnel were about 4,700 per 100,000 per year and for the United States, about 2,200 per 100,000.⁽²⁷⁾ The seemingly higher rates could be the result of universal, readily accessible medical coverage for all U.S. military personnel. Also, the higher rates could be due to the

frequent requirement for vigorous physical activity among military personnel that must be performed unless medically excused.

(H) Comparison of rates for specific causes of injuries for the military and the U.S. population may again be instructive. The annual rate of fall-related injury hospitalizations for the military is 50.5 per 100,000 Service members, which is substantially lower than for the U.S. population, where rates for 15 to 24 year old males is 89 per 100,000 and for 25 to 44 year olds is 125 per 100,000.⁽²⁷⁾ When looking at individual Services, rates of falls for the Army (79.5 per 100,000 per year) are more similar to the civilian data than the other Services.

(I) Annual rates of MV hospitalization for the military are 71.9 per 100,000. In comparison, for the United States, the rates are 100 per 100,000.⁽²⁷⁾ Rates of MV injuries reported for the United States for the age groups 15 to 24 years old and 25 to 44 years were 216 and 147, respectively.⁽²⁷⁾ When looking at the state level in 2004, the range of MV hospitalization rates among the 34 reporting states for 15 to 24 year olds were 53 to 246 per 100,000, with a median rate of 157.⁽²⁸⁾ For 25 to 34 year olds, the range of MV rates for the 34 states were 45 to 154 per 100,000 persons per year, with a median of 103.⁽²⁸⁾ Hospitalization rates for MV-related injuries among military personnel appear to be at the low end of the spectrum reported for states. If we examine the rate for just the Army, the best comparison population because they have greater opportunity to drive (do not spend time at sea), it is 91.5 per 100,000 per year (Table 3-1-7). This rate is still on the low side, compared to state-level civilian population data on younger age groups comparable to the Army population.

(J) It should not be surprising that military MV-related injury hospitalization rates are lower for the military than for the United States. Krull et al.,⁽³⁸⁾ showed that rates for comparable age groups of male Service members are lower than for civilian men of the same age. Relative rates of MV fatalities for U.S. men versus men of the same age in the Army for the age groups 20 to 24, 25 to 29, 30 to 34, 35 to 39, and 40 to 44, respectively, were 1.14, 1.46, 1.26, 1.41, and 1.29. Thus, men of comparable age in the U.S. population were at 14 percent to 46 percent higher risk of dying in a MV crash than Army men of the same age. Despite the expectation that military personnel (especially male Soldiers) might be greater risk takers than comparable aged civilians, a higher injury risk in MV or other “accident” statistics was not seen.

(K) The third leading cause of hospitalization for the military is sports, with an annual rate of 49.5 per 100,000. The rate of sports injury hospitalizations cannot be readily contrasted with civilian U.S. data due to the fact that sports/athletics do not receive a cause code in the ICD-9 E-code system. Unlike ICD-9 E-coded data, the STANAG injury-cause codes permit coding of specific sports (such as, softball, basketball, football, soccer, and so forth) and recreational activities (such as, skiing, rock climbing, horsemanship, swimming, and so forth). Another challenge to assessing sports and recreational injuries for both military and civilian communities is that a large portion of the injuries are overuse injuries such as stress fractures, Achilles tendonitis, plantar fasciitis, and patello-femoral syndrome, classified in the ICD-9-CM

code series 716 to 739.^(16, 19) These injury-related musculoskeletal conditions are not classified as “injuries” in the ICD-9 CM code book or by most injury epidemiologists. However, these conditions are commonly recognized as injuries by the sports medicine community (such as, orthopedic surgeons, physical therapists, athletic trainers, sports medicine practitioners, and so forth). The Military Injury Metrics Working Group in 2002 agreed that such conditions should be captured by military injury surveillance systems.^(15, 21) If these injury-related musculoskeletal conditions (chronic and overuse injuries) were not coded and tracked as injuries, 30 percent of hospitalizations (n = 3,532) and 52 percent of ambulatory injury visits (n = 589,828) would be missed by the military health services and safety officials.

(L) For the military, physical training or exercise-related injuries are the single biggest category of overuse injuries and would be missed altogether if not coded and tracked along with acute injury (ICD-9-CM 800-999) data. The data in Figure 3-1-3 represent LEOU injuries and were designed to track the effects of running and other injuries due to weight-bearing activities. This is an important issue for civilian communities, where similarly young or middle-aged, vigorously active individuals would also be expected to experience these kinds of injuries.

(3) DEVELOPMENT OF MILITARY INJURY SURVEILLANCE.

(A) Since the late 1980s, public health and injury experts have recommended surveillance of both fatal and nonfatal injuries.^(6, 11-14) In 1996, the AFEB recommended that the DOD develop a comprehensive medical injury surveillance system including hospitalization and outpatient data, and that surveillance of overuse/chronic injuries⁽³⁹⁾ in addition to acute injuries was needed.^(1, 2) Much has happened to improve military medical surveillance systems since then. The DMSS, established in 1997⁽⁴⁰⁾ at the direction of the Assistant Secretary of Defense for Health Affairs, started with surveillance of hospitalizations.⁽²⁾ In 1998, automated outpatient surveillance data became available through DMSS for all four Services in addition to hospitalization data that was already routinely used for disease surveillance. The addition of outpatient injury visit data greatly expanded the recognition of how important the problem of injuries is for the Services.

(B) Even though the current military medical surveillance system (that is, DMSS) has some flaws and/or weaknesses, it is evident from the preceding discussion that the Services have developed a system capable of significantly contributing to the prevention of injuries. The DMSS is population-based with both inpatient (hospital) and outpatient (ambulatory) data. The data on hospitalizations of military personnel, which has the characteristics recommended for the states to incorporate,^(6, 22) is virtually 100 percent complete. All hospitalizations in military treatment facilities are captured as well as those for which the military pays for care outside the military healthcare system. All cases have diagnosis codes (ICD-9 CM N-codes). These data are linked to personnel data containing demographic and occupational information on all Service members. About 75 percent of hospitalized injury cases are cause-coded with NATO codes.⁽²⁴⁾ Likewise, outpatient data for the military is virtually 100 percent completed. However, as

mentioned earlier, there is no cause coding for outpatient injuries. Outpatient data are also linked to demographic data for all service members. Data on age, race, sex, and military occupational skills are available for public health purposes.

(C) With regard to current reporting, medical surveillance data for hospitalization and ambulatory medical treatment of injuries is readily available in two forms for all four Services through the AFHSC. The first being an interactive queriable form, and the second being a location-based report. The first is the Defense Medical Epidemiology Database (DMED), which can be accessed at the AFHSC Web site: (<http://www.afhsc.army.mil/DMED>). The DMED data can be queried from limited access accounts in aggregate form that contains: (1) medical outcome (diagnosis) data for hospitalized and ambulatory cases, and (2) causes of injury hospitalizations (STANAG coded) linked with population data so rates and trends of hospitalization can be tracked back to 1989 and outpatient visits to 1998. Second, the AFHSC also produces monthly installation injury reports for all four Services for 172 installations worldwide (39 Army, 37 Navy, 80 Air Force, and 16 Marine Corps). The Installation Injury Reports contain seven metrics—

(1) Installation injury rates compared to the Service as a whole, or the Service rates to DOD rates overall;

(2) Trends in rates of injury by nine anatomical sites for the installation;

(3) Causes of injury hospitalization by major STANAG code categories;

(4) Distribution frequency of medical encounters from one to over five at the installation and for the Service overall;

(5) Frequency and percent of medical encounters by body location for installation and service overall;

(6) Severity of duty limitation as a percent of injuries for the installation and the Service; and

(7) Duty limitations by anatomical site.

(D) These reports are passively available on the AFHSC Web site: (<http://www.afhsc.army.mil/InjuryReports>). They might be more effective if they were directly sent to installation commanders and local medical and safety officials. Preferably, these reports should be sent at least annually and possibly with a rank-ordered list of overall injury rates for all installations.

(E) Injury and public health experts universally recommend use of hospitalization data for injury surveillance where it is available.^(6, 11-14) The State and Territorial Injury Prevention Directors Association (STIPDA) recommends population-based surveillance that tracks both injury hospitalizations and rates (that is, numerators, denominators, and incidences) of such hospitalizations in the United States.⁽²²⁾ The STIPDA provides a number of specific recommendations about how to use hospital discharge data for injury surveillance.⁽²²⁾ Their recommendations include—

i. Checking the quality of data (such as, completeness and percent of diagnosed injuries with cause codes among other things).

ii. Including hospitalized conditions that list an injury as the principle reason for admission.

iii. Calculating crude, unadjusted injury discharge rates, and sex-specific age-adjusted rates.

iv. Reporting frequencies of diagnoses by body location in the Barell Matrix format.

v. Describing causes of injury for which a valid external cause code (ICD-9-CM E code) exists using the recommended framework for presenting mortality and morbidity data.

Note: While military injury hospitalization data are cause-coded, they are not coded using ICD-9-CM E-codes but rather NATO STANAG injury cause codes.
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(F) This report demonstrates that, with the exception of reporting ICD-9-CM E-codes (the Services use NATO injury cause codes)⁽²⁴⁾, the DOD military hospitalization data can be reported in the manner suggested by STIPDA.

(4) MILITARY MEDICAL SURVEILLANCE AND INJURY PRIORITIES.

(A) There is a growing recognition of the value of medical surveillance to public health, safety, and injury prevention by both civilian^(6, 13) and military subject matter experts.^(1, 2) However, priorities for the military are still focused on fatal injuries—primarily MV and aviation crashes. Historically, there have only been a few hundred MV fatalities per Service each year and a few dozen aviation deaths⁽⁴¹⁾ compared to hundreds of thousands of injuries treated in hospitals and outpatient settings each year. These nonfatal injuries have a huge impact on the health and readiness of military of units. It has been estimated that nonfatal injuries result in almost 25 million days of limited duty annually for the Services.⁽¹⁰⁾ As shown in this paper, falls, sports, and physical fitness training result in far more nonfatal injuries than MV or aviation mishaps and should be given much higher priority for both prevention and research. To

successfully prevent these and other important, but overlooked, injuries will require a more systematic, evidence-based process with specified, objective criteria for setting priorities.

E. CONCLUSIONS AND RECOMMENDATIONS.

(1) The data presented in this paper clearly indicate that injuries are the biggest health problem of the Services for which medical care is sought. Furthermore, where comparisons can be made with U.S. population data, rates of injuries are similar and may, in some cases, be lower than for the United States and for some states. Because the cause-coding systems for the military (that is, STANAG codes) are substantially different from those employed by civilian hospitals (that is, ICD-9 CM and ICD-10), direct comparisons of cause-specific rates in most cases are not possible. Nevertheless, it appears that for significant injury causes (such as, falls and MV crashes), the rates of hospitalization for the military are not likely to be higher than those for comparable young U.S. male populations.

(2) The DOD has a well-established medical surveillance system that could be used more effectively than it is now. The system could be improved to be an even more potent resource for prevention in the future. Actions that could be taken to make more effective use of medical surveillance of nonfatal injuries are—

(A) Make greater use of medical data to identify the biggest problems.

(B) Monitor rates and trends in injuries to detect emerging injury problems, such as TBI, noise, and vision-related injuries.

(C) Set priorities based on data on the magnitude of nonfatal as well as fatal injuries and evidence of preventability.

(D) Make sure prevention of fall, sports, physical fitness training, military vehicle mishap, and handling of guns and explosives-related injuries are priorities for the DOD.

(E) Where evidence of effective prevention strategies exists, set prevention priorities.

(F) Where evidence of effective prevention does not exist but large or severe problems are identified, set research priorities—

i. For problems that military and civilian communities share, seek to ensure civilian research organizations recognize and share the priority (such as, fall and sports injury prevention).

ii. Where injury problems are unique to the military, develop processes to ensure military research priorities incorporate public health priorities (such as, military vehicle mishap-related injuries, falls from military vehicles, and blast-related TBIs).

(G) Evaluate all newly implemented injury prevention programs and policies and make sure surveillance data and metrics are available to monitor success.

(H) Make sure medical surveillance data and evidence of prevention effectiveness reach installation and unit commanders and installation safety and medical authorities.

(I) IMPROVE NONFATAL INJURY SURVEILLANCE.

i. Report rates of injury for ED treatment separately from other outpatient treatment to allow for comparisons to national and state data.

ii. Ensure the same coding systems are used by the military as for civilian U.S. medical care for purposes of comparability.

iii. Establish cause coding of injuries treated in outpatient settings.

(3) Current DOD attention to injury prevention offers the military medical departments an opportunity to contribute to the prevention of the single biggest health problem of the Services. The DOD and the Services have, at their disposal, an excellent medical surveillance system to monitor injury-related health outcomes and the success of injury prevention programs. If outpatient data systems are improved, the DOD has an opportunity to perform two important actions: (1) making a tremendous contribution to the prevention of injuries among Active Duty military personnel; and (2) establishing a model for future data-driven, evidence-based injury prevention.

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3-2. MUSCULOSKELETAL/OVERUSE INJURIES: DESCRIPTION OF AN UNDER-RECOGNIZED INJURY PROBLEM AMONG U.S. MILITARY PERSONNEL

A. INTRODUCTION.

(1) Injuries are recognized as a leading health problem in the United States.^(1, 2) In 2002, 161,269 persons died as the result of injuries (unintentional and intentional).⁽³⁾ Fatal unintentional injuries (n=106,742) constituted the 5th leading cause of all deaths after diseases of the heart, malignant neoplasms, cerebrovascular disease, and chronic lower respiratory disease and was the leading cause of death for those under 45 years of age.⁽³⁾ Fatal intentional injuries from suicide and homicide ranked 11th and 14th, respectively.⁽³⁾ Each year, an estimated 1.5 million persons with injuries are discharged from hospitals, representing the 2nd most common discharge diagnosis⁽²⁾ and 30 million persons are treated for injuries in hospital emergency departments (ED) (2001), accounting for 30 percent of all ED visits.^(2, 4)

(2) Data for the Services similarly demonstrate the magnitude of the injury problem within the U.S. Department of Defense (DOD). In 2003, unintentional injury was the leading cause of death, representing 55 percent of fatalities among Active Duty military personnel.⁽⁵⁾ Intentional deaths from suicides and homicides comprised an additional 17 percent of fatalities. In 2003, there were more hospitalizations for injury among Active Duty personnel (n=9,605) than for any other diagnosis category except pregnancy-related conditions.⁽⁶⁾ In 2004, there were 555,393 injuries treated in ambulatory clinics throughout DOD.⁽⁵⁾

(3) Even though these data clearly demonstrate that injuries are a leading health problem, many civilian and military injury experts are convinced that these data significantly underestimate the actual magnitude of the injury problem.⁽⁷⁻⁹⁾ In the civilian and military studies cited above, an injury was defined as “bodily harm” resulting from acute exposure to external forces or substances (that is, mechanical, thermal, electrical, chemicals, or radiant) and drowning.⁽⁴⁾ Using this case definition, only traumatic injuries having relatively sudden discernible effects are included in injury reporting.^(4, 10, 11) These traumatic injuries are classified in Chapter 17 (Injury and Poisoning) of the International Classification of Diseases, 9th Revision-Clinical Modification, (ICD-9-CM). Similarly, the case definition for reporting fatal injuries only included cases classified in Chapter 17 (Injury and Poisoning) of the International Classification of Diseases, 10th Revision–Clinical Modification (ICD-10-CM: codes S00-T98).⁽³⁾ However, many injuries that occur in recreation, sports, and the workplace are not classified in these chapters and are, consequently, not included in injury estimates using this limited definition. Examples of common injuries not included are: (1) meniscal tears and other internal derangements of the knee, (2) recurrent shoulder dislocations, (3) rotator cuff tendinitis and tears, (4) Achilles tendinitis, (5) stress fractures, and (6) injury-related cervical and lumbar strains (with or without neurological involvement). These injuries are classified in Chapter 13 (Diseases of the Musculoskeletal System and Connective Tissue), ICD-9-CM.

(4) The Barell Injury Matrix is commonly used in civilian and military injury surveillance to categorize traumatic injuries from Chapter 17, ICD-9-CM. This matrix was initially developed by injury experts working with the Israeli Defense Forces and the International Collaborative Effort on Injury Statistics (ICEIS) in 1997.^(12, 13) The current version was finalized and accepted by the ICEIS in 2001. By categorizing injuries by injury type and body region, it allows injury experts to recognize the degree to which specific injury types contribute to the injury problem and identify focus areas for prevention. Adding to its utility, it allows comparison of injuries over time and between different populations. However, since the matrix presents data on traumatic injuries (Chapter 17, ICD-9-CM) but not injury-related musculoskeletal conditions (Chapter 13, ICD-9-CM), it under-represents the true magnitude of the injury problem as described previously.

(5) Injury experts in sports and occupational medicine have developed expanded injury definitions that more fully encompass the full array of injuries common in these fields. In addition to the traumatic injuries in Chapter 17, ICD-9-CM and represented in the Barell Matrix, these definitions include a subset of musculoskeletal conditions from Chapter 13, ICD-9-CM that is injury related when considering the specific population of interest.⁽¹⁴⁻²⁷⁾ To reinforce the importance of these injury-related musculoskeletal conditions in sports, inclusion of these injuries as well as the traumatic injuries (Chapter 17, ICD-9-CM), has become standard in many well-accepted sports injury surveillance systems, including those maintained by the National Collegiate Athletic Association and international governing bodies for many sports including soccer and rugby.⁽²⁸⁻³²⁾

(6) Though acute trauma may be a factor in some cases, many of these injury-related musculoskeletal conditions typically result from the cumulative effects of smaller amplitude (micro-traumatic) forces such as occur with overtraining, overexertion, repetitive movements and activities, forceful actions, vibratory forces, extreme joint positions, and prolonged static positioning.^(15-19, 21, 33-40) These types of forces and the injuries they cause are common in many types of physical activity (that is, leisure activities, exercise, recreation, and sports)^(26, 27, 33, 35, 41-45) and in many occupational settings including the military.^(36-39, 46-53)

(7) During 2001 and 2002, three groups within DOD worked independently to develop a comprehensive list of injury-related diagnosis codes that could be used for injury surveillance in the Services and DOD. These groups were the: (1) Army Medical Surveillance Activity, (2) DOD Military Injury Metrics Working Group, and (3) Injury Prevention Program, U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). The groups realized the importance of expanding the injury case definition that included only traumatic injuries from Chapter 17, ICD-9-CM to also include the subset of musculoskeletal conditions from Chapter 13, ICD-9-CM that are typically injury-related when considering the military population. The combined efforts and products of these groups contributed greatly to DOD's acceptance of a broader injury definition that included injury-related musculoskeletal conditions and traumatic injuries for injury surveillance, analysis, and reporting.^(54, 55)

(8) The purpose of this section is to: (1) describe the process used by the USACHPPM to select a standardized set of injury-related musculoskeletal conditions to be used for injury surveillance, (2) describe the development of an injury-related musculoskeletal condition matrix to classify these injuries by injury type and body region, (3) report the musculoskeletal injury incidence and rate among the combined Services (DOD) for calendar year 2006, and (4) present the DOD musculoskeletal injury data for 2006 using the injury-related musculoskeletal condition matrix.

B. METHODS.

(1) A team of injury epidemiologists, physicians, and physical therapists at the Injury Prevention Program, USACHPPM, met with the purpose of identifying the subset of musculoskeletal conditions from Chapter 13, ICD-9-CM that should be included when describing the burden of injury in the predominantly young and physically active military population. The team reviewed data from: (1) established Army injury surveillance systems, (2) injury field investigations, (3) extensive medical record reviews (more than 8,000 medical records), and (4) peer-reviewed scientific literature. At the completion of this review, the team systematically evaluated all injury-related musculoskeletal conditions classified in Chapter 13 to decide which should be included in future injury surveillance efforts. Consensus of group members was required in this decision process. The final set of injury-related musculoskeletal conditions and their ICD-9-CM diagnosis codes are presented in Appendix A.

(2) To categorize injury-related musculoskeletal conditions according to their injury type and anatomical location (body region) and to provide a standardized format for reporting these injuries, a matrix modeled after the Barell Injury Matrix⁽¹²⁾ was developed. This injury-related musculoskeletal condition matrix (Table 3-2-1) incorporated the identified diagnosis codes from Chapter 13, ICD-9-CM (Appendix A). In this matrix, injury-type categories are identified by column headings along the upper horizontal axis. The injury-type categories represent general types of injury-related musculoskeletal conditions and do not reflect specific diagnosis categories from Chapter 13, ICD-9-CM. The first injury-type category—*inflammation and pain (overuse)*—includes injuries that are characterized by inflammation and pain due to physical damage of the body resulting from low magnitude forces (micro-trauma) associated with overuse injuries. Examples of musculoskeletal conditions in this category include traumatic arthropathy (716.1), rotator cuff tendinitis (726.10), bicipital tenosynovitis (726.12), patellar tendinitis (726.64), and Achilles tendinitis (726.71). The 2nd and 3rd categories include injury-related musculoskeletal conditions that involve a joint derangement without and with, respectively, neurological involvement. These injuries can result from traumatic or micro-traumatic (overuse) forces and include meniscal tears of the knee (717.0-717.5), loose bodies in the knee (717.6), articular cartilage disorders (718.0), intervertebral disc disorders of the cervical (722.0) or lumbar spine (722.1), lumbosacral radiculitis (724.4), and intervertebral disc disorders with myelopathy (722.7). The 4th category, *stress fractures*, is a well recognized overuse injury. Common stress fractures include the tibia (733.93) and the metatarsals (733.94). The last two

categories—sprains/strains/ruptures and dislocations—are comprised of injuries that can result from acute trauma or cumulative microtrauma (overuse). Examples of sprains/strains/ruptures include old disruption (reinjury) of the medial collateral ligament (717.81) and nontraumatic rupture of the quadriceps tendon (727.65) or patellar tendon (727.66). A common example of “dislocations” is recurrent shoulder dislocation (718.31).

TABLE 3-2-1. INJURY-RELATED MUSCULOSKELETAL CONDITION MATRIX WITH ASSIGNED ICD-9 CODES

Injury Location			Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurological Involvement	Stress Fracture	Sprains/Strains/Rupture	Dislocation
	Vertebral Column	Cervical	723.1	722.0	722.71, 723.4			
		Thoracic/Dorsal		722.11	722.72, 724.4			
		Lumbar	724.2	722.10	722.73, 724.3			
		Sacrum, Coccyx	720.2					
		Spine, Back Unspecified	721.7, 724.5	722.2	722.70, 724.9	733.13		
Extremities	Upper	Shoulder	716.11, 719(.01,.11,.41), 726(.0,.1,.2)	718(.01,.11,.81,.91)			727(.61-.62)	718.31
		Upper arm, Elbow	716.12, 719(.02,.12,.42), 726.3	718(.02,.12,.82,.92)		733.11		718.32
		Forearm, Wrist	716.13, 719(.03,.13,.43), 726.4	718(.03,.13,.83,.93)		733.12		718.33
		Hand	716.14, 719(.04,.14,.44)	718(.04,.14,.84,.94)			727(.63-.64)	718.34
	Lower	Pelvis, Hip, Thigh	716.15, 719(.05,.15,.45), 726.5	718(.05,.15,.85,.95)		733(.14-.15)	727.65	718.35
		Knee, Lower leg	716.16, 717.7, 719(.06,.16,.46), 726.6	717(.0-.6,.9), 718(.06,.16,.86,.96)		733(.16,.93-.94)	717.8, 727(.66-.67)	718.36
		Ankle, Foot	716.17, 719(.07,.17,.47), 726.7, 728.71, 734	718(.07,.17,.87,.97)			727.68	718.37
Unclassified by Site	Others and Unspecified	Other specified/Multiple	716(.18-.19), 719(.08-.09,.18-.19,.48-.49), 726.8, 727.2	718(.08,.09,.18,.19,.88,.89,.98,.99)		733.19	727.69	718(.38,.39)
		Unspecified Site	716.10, 719(.00,.10,.40), 726.9, 727.3, 729.1	718(.00,.10,.80,.90)	729.2	733(.10,.95)	727.60, 728.83	718.30

(3) The body region categories and subcategories are identified by row headings along the left vertical axis of the matrix. The major body region categories are: (1) vertebral column, (2) upper extremity, and (3) lower extremity. The last category, “other and unspecified,” includes injuries that cannot be classified by body region from their ICD-9-CM diagnosis codes. In comparing the body region categories and subcategories in the injury-related musculoskeletal condition matrix to the corresponding categories in the Barell Injury Matrix, a few important differences are noted—

(A) The injury-related musculoskeletal condition matrix does not include the “head and neck” body region category and its two corresponding subcategories (that is, “traumatic brain injury” and “other head/face/neck”). These injuries are classified in Chapter 17, ICD-9-CM.

(B) The injury-related musculoskeletal condition matrix does not include the “spinal cord” subcategory of the “spine and trunk” body region category. Spinal cord injuries are classified in Chapter 17, ICD-9-CM.

(C) The injury-related musculoskeletal condition matrix does not include the “torso” body region category since injuries in this body region are usually internal injuries, not musculoskeletal injuries. Torso injuries are classified in Chapter 17, ICD-9-CM.

(D) In the injury-related musculoskeletal condition matrix, the “upper” and “lower” subcategories of the “extremity” body region differ somewhat from those in the Barell Injury Matrix because of classification differences between Chapters 13 and 17, ICD-9-CM. For example, upper extremity subcategories in the injury-related musculoskeletal condition matrix, according to the body regions used in Chapter 13, ICD-9-CM, are: (1) shoulder, (2) upper arm and elbow, (3) forearm and wrist, and (4) hand and fingers. Upper extremity subcategories in the Barell Matrix, based on body regions used in Chapter 17, ICD-9-CM, are: (1) shoulder and upper arm, (2) forearm and elbow, and (3) wrist, hand and fingers. Similar differences are noted in the lower extremity groupings.

(4) The identified injury-related musculoskeletal condition diagnosis codes were provided to the U.S. Armed Forces Health Surveillance Center (formerly, the U.S. Army Medical Surveillance Activity), which maintains and manages the Defense Medical Surveillance System (DMSS).⁽⁵⁶⁾ Using these codes, injuries that occurred during calendar year 2006 were identified in the DMSS inpatient and outpatient electronic medical records for all nondeployed, Active Duty DOD military personnel. Multiple medical encounters (hospitalizations or outpatient visits) for the same musculoskeletal injury diagnosis (ICD-9-CM) within 60 days of the first hospitalization or outpatient visit were excluded to reduce the effect of follow-up visits. To capture all injury-related musculoskeletal conditions and not just those for which the musculoskeletal injury was the primary reason for the visit, both primary and nonprimary injury-related musculoskeletal diagnoses for the same hospitalization or outpatient visit were obtained.

(5) The total number of injury-related musculoskeletal conditions with ICD-9-CM diagnosis codes assigned to cells in the injury-related musculoskeletal condition matrix was entered into the appropriate matrix cells. Totals and proportions were calculated for each injury type category (columns) and for each body region subcategory (rows). Data were also entered into a simplified matrix that combined the body region subcategories into the four major categories (that is, vertebral column, upper extremity, lower extremity, and others/unspecified). This simplified matrix was used to make general observations about injuries affecting the major body regions.

(6) The 2006 injury rate for these injury-related musculoskeletal conditions was calculated using the total number of injuries and the 2006 nondeployed person-time for the combined Services (1,183,780 person-years) obtained from the U.S. Armed Forces Health Surveillance Center.

C. RESULTS.

(1) Overall, there were 743,547 injury-related musculoskeletal conditions in 2006 among Active Duty, nondeployed Service members in DOD, including primary and secondary diagnoses from outpatient visits and hospitalizations. Using the nondeployed person-time for 2006, the injury rate was 628 injuries per 1,000 person-years.

(2) The Active Duty injury-related musculoskeletal matrix for outpatient visits and hospitalization provides the frequencies of these musculoskeletal conditions categorized by their injury type and body region. Table 3-2-2 is a simplified matrix in which body region subcategories were collapsed into the major body region categories. In this simplified matrix, injuries involving the vertebral column and lower extremity accounted for nearly equal proportions of all injuries (40.3 percent and 39.0 percent, respectively), while upper extremity injuries comprised 14.1 percent of the total. Inflammation and pain (overuse) was the largest injury type category, including 82.3 percent of all injuries. The remaining five injury-type categories represented smaller proportions ranging from 8.7 percent for other joint derangements to only 0.4 percent for dislocations. Inflammation and pain (overuse) injuries of the lower extremity (n=256,268; 34.5 percent) and vertebral column (n=228,969; 30.8 percent) were the leading two individual cells in the simplified matrix. Common examples of injuries in these categories included trochanteric bursitis of the hip (726.5), patellar tendinitis 726.64, Achilles tendinitis (726.71), plantar fasciitis (728.71), joint effusions of the knee (719.06) and ankle (719.07), and common overuse disorders of the neck (723.1) and back (724.2 and 724.5). The next largest cell, joint derangement with neurological involvement in the vertebral column, included only 38,731 (5.2 percent) injuries.

TABLE 3-2-2. SIMPLIFIED INJURY-RELATED MUSCULOSKELETAL CONDITION MATRIX FOR OUTPATIENT VISITS AND HOSPITALIZATIONS, ACTIVE DUTY MILITARY, 2006^{a-d}

Injury Location		Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurological Involvement	Stress Fracture	Sprains/Strains/Rupture	Dislocation	Total	Percent Total
Spine and Back	Vertebral Column	228,969	31,502	38,731	283	0	0	299,485	40.3%
Extremities	Upper	91,035	8,338	0	55	3,301	2,479	105,208	14.1%
	Lower	256,268	24,382	0	6,979	1,935	787	290,351	39.0%
Unclassified by Site	Others and Unspecified	35,572	638	5,048	6,665	544	36	48,503	6.5%
Total		611,844	64,860	43,779	13,982	5,780	3,302	743,547	
Percent Total		82.3%	8.7%	5.9%	1.9%	0.8%	0.4%		100%

Notes:

^a Includes injury-related musculoskeletal conditions from outpatient visits and hospitalizations.^b Multiple medical encounters (outpatient visits or hospitalizations) for the same injury-related musculoskeletal condition diagnosis (ICD-9-CM) within 60 days of the first hospitalization or outpatient visit were excluded.^c Source: DMSS.^d Prepared by Army Medical Surveillance Activity, the USACHPPM, (October 8, 2007).

(3) In the full matrix (Table 3-2-3), the 6 largest sub-categories for body region were the knee/lower leg, lumbar region, ankle/foot, spine/back unspecified, shoulder, and cervical region. Together these accounted for 81.6 percent of all injury-related musculoskeletal conditions. The knee/lower leg and ankle/foot sub-categories represented 57.3 percent and 33.3 percent, respectively, of lower extremity injuries, and 22.4 percent and 13.0 percent, respectively, of all injuries in the matrix. Injuries involving the lumbar region accounted for 48.5 percent of vertebral column injuries and 19.5 percent of all injuries, while cervical injuries comprised 16.8 percent of vertebral column injuries and only 6.8 percent of all injuries. The shoulder was the largest sub-category of the upper extremity, comprising 63.2 percent of the upper extremity injuries and 8.9 percent of all injuries.

(4) The seven highest frequency cells in the full matrix were in the inflammation and pain (overuse) category and involved the following body region subcategories, in decreasing order: knee/lower leg, lumbar spine, ankle/foot, spine unspecified, shoulder, cervical spine, and pelvis/hip/thigh. Following these, the next three leading cells were joint derangements of the lumbar spine, pain and inflammation (overuse) of the forearm, and joint derangements with neurological involvement of the thoracic spine.

D. DISCUSSION.

(1) This section offers the first description and implementation of the injury-related musculoskeletal condition matrix. It categorizes the selected musculoskeletal conditions by injury type and body region, using a format similar to that used in the Barell Injury Matrix for traumatic injuries (Chapter 17, ICD-9-CM). By classifying injury-related musculoskeletal condition into these categories, the matrix allows injury experts to recognize the degree to which specific injury types and/or body regions contribute to the injury problem and assists in identifying areas for targeted prevention strategies. This matrix also provides a standardized format for comparing injury-related musculoskeletal conditions over time and between populations.

(2) The injury-related musculoskeletal conditions included in this analysis were identified by a team of injury epidemiologists, physicians, and physical therapists at USACHPPM. Though some of these injuries may result from acute traumatic causes, they more often result from the cumulative effect of micro-traumatic forces that are common in many physical activities and work settings. In the sports medicine literature, injuries of this latter type are commonly referred to as “overuse injuries” and are activity-related (that is, due to recreation, physical training, sports, and so forth). When they are work-related, they are often referred to as “repetitive strain injuries,” “cumulative trauma disorders,” or “work-related musculoskeletal disorders.”^(15, 16, 33, 34, 38, 41, 49) Activities commonly associated with injury-related musculoskeletal conditions can involve: (1) overtraining, (2) overexertion, (3) repetitive movements and activities, (4) forceful actions, (5) vibratory forces, (6) extreme joint positions, and (7) prolonged static postures.^(15-19, 21, 35, 37-41, 49, 57) In addition to their direct effect in causing new injuries, these

microtraumatic forces may also exacerbate or extend previous injuries, or cause previous injuries to recur such as in recurrent joint (shoulder) dislocations and recurrent back strains.⁽⁵⁸⁻⁶⁰⁾

TABLE 3-2-3. INJURY-RELATED MUSCULOSKELETAL CONDITION MATRIX FOR OUTPATIENT VISITS AND HOSPITALIZATIONS, ACTIVE DUTY, 2006^{a-d}

Injury Location			Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurological Involvement	Stress Fracture	Sprains/Strains/ Rupture	Dislocation	Total	Percent Total
Spine and Back	Vertebral Column	Cervical	36,932	5,390	7,972	0	0	0	50,294	6.8%
		Thoracic/Dorsal	0	751	15,244	0	0	0	15,995	2.2%
		Lumbar	114,562	18,078	12,684	0	0	0	145,324	19.5%
		Sacrum Coccyx	4,720	0	0	0	0	0	4,720	0.6%
		Spine, Back Unspecified	72,755	7,283	2,831	283	0	0	83,152	11.2%
Extremities	Upper	Shoulder	54,460	7,014	0	0	2,644	2,368	66,486	8.9%
		Upper arm, Elbow	7,392	313	0	18	0	33	7,756	1.0%
		Forearm, Wrist	18,037	691	0	37	0	28	18,793	2.5%
		Hand	11,146	320	0	0	657	50	12,173	1.6%
	Lower	Pelvis, Hip, Thigh	26,509	394	0	179	229	23	27,334	3.7%
		Knee, Lower leg	140,161	17,490	0	6,800	1,335	535	166,321	22.4%
		Ankle, Foot	89,598	6,498	0	0	371	229	96,696	13.0%
Unclassified by Site	Others and Unspecified	Other specified/Multiple	5,882	273	0	404	114	16	6,689	0.9%
		Unspecified Site	29,690	365	5,048	6,261	430	20	41,814	5.6%
Total			611,844	64,860	43,779	13,982	5,780	3,302	743,547	
Percent Total			82.3%	8.7%	5.9%	1.9%	0.8%	0.4%		100%

Notes:

^a Includes injury-related musculoskeletal conditions from outpatient visits and hospitalizations.^b Multiple medical encounters (outpatient visits or hospitalizations) for the same injury-related musculoskeletal condition diagnosis (ICD-9-CM) within 60 days of the first hospitalization or outpatient visit were excluded.^c Source: DMSS.^d Prepared by the USACHPPM, Army Medical Surveillance Activity, (October 8, 2007).

(3) While there were 540,000 injuries among non-deployed military service members in 2006 where a musculoskeletal condition was the primary diagnosis, there were a total of 743,547 injuries for which a musculoskeletal condition was the primary or non-primary diagnosis. This seemingly high injury count represents only the injury-related musculoskeletal conditions and does not include the traumatic injuries classified in Chapter 17, ICD-9-CM. To determine the overall injury incidence for the Services, the number of traumatic injuries must be added to the number of injury-related musculoskeletal conditions herein reported. When this is done, there are nearly 2 million injuries per year.⁽⁶¹⁾

(4) Injuries classified in the inflammation and pain (overuse) category comprised 82.3 percent of all injury-related musculoskeletal conditions. Within this category, 22.9 percent of injuries involved the knee/lower leg, followed by the lumbar region (18.7 percent) and the ankle/foot (14.6 percent). Common examples of injuries in this category include: (1) joint enthesopathies (that is, rotator cuff tendinitis, hip bursitis, patellar tendinitis, Achilles tendinitis), (2) inflammation and pain of joints (that is, joint pain, effusion, and hemarthrosis), and (3) common overuse disorders of the neck and back.

(5) Even though the other injury types categorized in the injury-related musculoskeletal matrix were proportionally much smaller, their contribution to the total number of injuries was significant (n=131,703). The musculoskeletal conditions classified as joint derangements accounted for 8.7 percent of all injuries. Within this category, 28 percent of injuries involved the lumbar region and 27 percent involved the knee/lower leg. These injuries result from traumatic or microtraumatic (overuse) forces and include intervertebral disc disorders of the cervical and lumbar spines, meniscal tears of the knee, and other knee internal derangements. The injuries classified as “joint derangements with neurological involvement” represented 5.9 percent of all injuries and 88.5 percent of these involved the vertebral column. Examples of these injuries include cervical radiculitis, lumbosacral radiculitis, and intervertebral disc disorders with myelopathy. Stress fractures were infrequent overuse injuries (1.9 percent of all injuries) but can have serious consequences that include long recovery times, possibility of surgery, potential disability, and discharge from military Service. Joint injuries classified as sprains/strains/ruptures and dislocations accounted for only 0.8 percent and 0.4 percent of all injury-related musculoskeletal conditions and primarily involved the shoulder and knee/lower leg.

(6) Investigations within the military have provided convincing evidence that many injuries among Service members are of the type routinely classified as injury-related musculoskeletal conditions and that most have an identifiable cause of injury.^(33, 34, 41, 46, 48, 49, 57, 62-75) In one investigation, the USACHPPM Injury Prevention Program compared the ICD-9-CM diagnosis codes from the Standardized Ambulatory Data Record (SADR) to the medical provider’s hand-written patient history and diagnosis in the outpatient medical record for 408 outpatient encounters at Fort Riley, Kansas (military police and armor personnel).⁽⁷⁶⁾ Reviewers looked specifically at encounters that had been assigned ICD-9-CM diagnosis codes in the “diseases of the musculoskeletal system and connective tissue” code series. Of the 408 cases,

330 (81 percent) were described as injuries in the patient history notes in the outpatient medical record. In 80 percent of these cases (266/330), a specific injury cause was noted by the medical provider. Considering the specified injury cause and diagnosis, medical record reviewers classified 222 (67 percent) of these injuries as overuse injuries, 103 (31 percent) as traumatic injuries, and 5 (2 percent) were not classifiable. It was not surprising that nearly one-third of these injuries were classified as traumatic injuries, given that musculoskeletal conditions, such as shoulder dislocations and lumbar strains, could often be attributed to a traumatic event.

(7) Based on results of these past studies, many injury researchers and epidemiologists in the U.S. military now routinely include injury-related musculoskeletal conditions (Chapter 13, ICD-9-CM) and traumatic injuries (Chapter 17, ICD-9-CM) in their injury case definition when evaluating the injury incidence and burden in military sub-populations.^(47, 63-66, 77-79) In two recent investigations of injuries among members of the U.S. Army Band in 2004 and 2005, injury-related musculoskeletal conditions accounted for 61 percent and 56 percent of all injuries, respectively.^(63, 80) Causes of these injuries included: (1) physical activity (that is, leisure, recreation, exercise, and sports), (2) job-specific activities, and (3) other military training (that is, drill and ceremony, weapons ranges, and so forth). A significant underrepresentation of the actual injury problem would have resulted if the injury-related musculoskeletal conditions had not been included in this and other investigations.

(8) Adding further support to the inclusion of these injury-related musculoskeletal conditions in injury surveillance and reporting, evaluations involving subpopulations within the military have identified specific risk factors and causes for many of these musculoskeletal conditions. They have demonstrated that these injuries can be significantly reduced through targeted interventions.^(47, 57, 64, 66, 77, 78, 81, 82) For example, lower-extremity-overuse injuries associated with running, marching, and other lower-extremity, load-bearing activities accounted for up to 75 percent of injuries among men and 78 percent of injuries among women during Army basic training.⁽⁶⁸⁾ Prevention strategies that included slower progression of running distance, reducing total running volume, running in ability groups, and greater variety in types of training exercises (that is, multiaxial, neuromuscular, proprioceptive, and agility exercises) reduced the overuse injury risk by 52 percent in men and 46 percent in women.⁽⁷⁸⁾

E. CONCLUSIONS.

(1) In 2006, there were 743,547 injuries (including primary and non-primary diagnoses) among nondeployed Services members that involved injury-related musculoskeletal conditions selected from Chapter 13, ICD-9-CM (rate: 628 injuries per 1,000 person-years). To recognize the full extent of the Active Duty injury problem, however, this injury incidence must be added to the traumatic injury (Chapter 17, ICD-9-CM) incidence. Combined, the overall injury incidence would be almost 2 million injuries per year.

(2) The injury-related musculoskeletal condition matrix presented in this section is a useful tool for classifying the injury-related musculoskeletal conditions by their injury type and body region. The matrix can be used to compare injuries over time and between different populations. It also enables injury investigators and policy makers to focus attention on the highest frequency injuries and injury types to develop prevention strategies. Injury cause data can be used to target prevention of these injuries in risky activities.

F. RECOMMENDATIONS.

(1) Future DOD injury analyses and reports should include the injury-related musculoskeletal conditions classified in Chapter 13, ICD-9-CM, as well as the traumatic injuries classified in Chapter 17, ICD-9-CM. Only by including both injury types will the true magnitude of the DOD injury problem be fully recognized.

(2) The injury-related musculoskeletal condition matrix should be used in the DOD to classify injury-related musculoskeletal conditions and to compare injury incidence and rates over time and between different sub-populations.

(3) Injury-cause coding of all injuries should be required so prevention efforts can be directed at specific injury causes.

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**APPENDIX A. ICD-9-CM DIAGNOSIS CODES INCLUDED IN THE INJURY-RELATED
MUSCULOSKELETAL CONDITION MATRIX**

ICD-9-CM Diagnosis Code	Brief Description of ICD-9-CM Diagnosis Code	Injury Type—Injury-related Musculoskeletal Condition Matrix
716.1*	Traumatic arthropathy	Inflammation and Pain
717	Internal derangement of knee	Joint Derangement
717.0	Old bucket handle tear of medial meniscus	Joint Derangement
717.1	Derangement of anterior horn of medial meniscus	Joint Derangement
717.2	Derangement of posterior horn of medial meniscus	Joint Derangement
717.3	Other and unspecified derangement of medial meniscus	Joint Derangement
717.4	Derangement of lateral meniscus	Joint Derangement
717.40	Derangement of lateral meniscus, unspecified	Joint Derangement
717.41	Bucket handle tear of lateral meniscus	Joint Derangement
717.42	Derangement of anterior horn of lateral meniscus	Joint Derangement
717.43	Derangement of posterior horn of lateral meniscus	Joint Derangement
717.49	Other derangement of lateral meniscus	Joint Derangement
717.5	Derangement of meniscus, not elsewhere classifiable	Joint Derangement
717.6	Loose body in knee	Joint Derangement
717.7	Chondromalacia of patella	Inflammation and Pain
717.8	Other internal derangement of knee	Sprain/Strain/Rupture
717.81	Old disruption of lateral collateral ligament	Sprain/Strain/Rupture
717.82	Old disruption of medial collateral ligament	Sprain/Strain/Rupture
717.83	Old disruption of anterior cruciate ligament	Sprain/Strain/Rupture
717.84	Old disruption of posterior cruciate ligament	Sprain/Strain/Rupture
717.85	Old disruption of other ligaments of knee	Sprain/Strain/Rupture
717.89	Other internal derangement of knee	Sprain/Strain/Rupture
717.9	Unspecified internal derangement of knee	Joint Derangement
718.0*	Articular cartilage disorder	Joint Derangement
718.1*	Loose body in joint	Joint Derangement
718.3*	Recurrent dislocation of joint	Dislocation
718.8*	Other joint derangement, not elsewhere classifiable	Joint Derangement

ICD-9-CM Diagnosis Code	Brief Description of ICD-9-CM Diagnosis Code	Injury Type—Injury-related Musculoskeletal Condition Matrix
718.9*	Unspecified derangement of joint	Joint Derangement
719.0*	Effusion of joint	Inflammation and Pain
719.1*	Hemarthrosis	Inflammation and Pain
719.4*	Pain in joint	Inflammation and Pain
720.2	Sacroiliitis, not elsewhere classifiable	Inflammation and Pain
721.7	Traumatic spondylopathy	Inflammation and Pain
722.0	Displacement of cervical intervertebral disc without myelopathy	Joint Derangement
722.10	Displacement of lumbar intervertebral disc without myelopathy	Joint Derangement
722.11	Displacement of thoracic intervertebral disc without myelopathy	Joint Derangement
722.2	Displacement of intervertebral disc, site unspecified, without myelopathy	Joint Derangement
722.70	Intervertebral disc disorder with myelopathy, unspecified region	Joint Derangement with Neurological Involvement
722.71	Intervertebral disc disorder with myelopathy, cervical region	Joint Derangement with Neurological Involvement
722.72	Intervertebral disc disorder with myelopathy, thoracic region	Joint Derangement with Neurological Involvement
722.73	Intervertebral disc disorder with myelopathy, lumbar region	Joint Derangement with Neurological Involvement
723.1	Cervicalgia	Inflammation and Pain
723.4	Brachial neuritis or radiculitis not otherwise specified	Joint Derangement with Neurological Involvement
724.2	Lumbago	Inflammation and Pain
724.3	Sciatica	Joint Derangement with Neurological Involvement
724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified	Joint Derangement with Neurological Involvement
724.5	Backache, unspecified	Inflammation and Pain
724.9	Other unspecified back disorders	Joint Derangement with Neurological Involvement
726.0	Adhesive capsulitis of shoulder	Inflammation and Pain
726.1	Rotator cuff syndrome of shoulder and allied disorders	Inflammation and Pain
726.10	Disorders of bursae and tendons in shoulder region, unspecified	Inflammation and Pain

ICD-9-CM Diagnosis Code	Brief Description of ICD-9-CM Diagnosis Code	Injury Type—Injury-related Musculoskeletal Condition Matrix
726.11	Calcifying tendinitis of shoulder	Inflammation and Pain
726.12	Bicipital tenosynovitis	Inflammation and Pain
726.19	Other specified disorders	Inflammation and Pain
726.2	Other affections of shoulder region, not elsewhere classifiable	Inflammation and Pain
726.3	Enthesopathy of elbow region	Inflammation and Pain
726.30	Enthesopathy of elbow, unspecified	Inflammation and Pain
726.31	Medial epicondylitis	Inflammation and Pain
726.32	lateral epicondylitis	Inflammation and Pain
726.33	Olecranon bursitis	Inflammation and Pain
726.39	Other enthesopathy of elbow region	Inflammation and Pain
726.4	Enthesopathy of wrist and carpus	Inflammation and Pain
726.5	Enthesopathy of hip region	Inflammation and Pain
726.6	Enthesopathy of knee	Inflammation and Pain
726.60	Enthesopathy of knee, unspecified	Inflammation and Pain
726.61	Pes anserinus tendinitis or bursitis	Inflammation and Pain
726.62	Tibial collateral ligament bursitis	Inflammation and Pain
726.63	Fibular collateral ligament bursitis	Inflammation and Pain
726.64	Patellar tendinitis	Inflammation and Pain
726.65	Prepatellar bursitis	Inflammation and Pain
726.69	Other enthesopathy of knee	Inflammation and Pain
726.7	Enthesopathy of ankle and tarsus	Inflammation and Pain
726.70	Enthesopathy of ankle and tarsus, unspecified	Inflammation and Pain
726.71	Achilles bursitis or tendinitis	Inflammation and Pain
726.72	Tibialis tendinitis	Inflammation and Pain
726.73	Calcaneal spur	Inflammation and Pain
726.79	Other enthesopathy of ankle and tarsus	Inflammation and Pain
726.8	Other peripheral enthesopathies	Inflammation and Pain

ICD-9-CM Diagnosis Code	Brief Description of ICD-9-CM Diagnosis Code	Injury Type—Injury-related Musculoskeletal Condition Matrix
726.9	Unspecified enthesopathy	Inflammation and Pain
726.90	Enthesopathy of unspecified site	Inflammation and Pain
726.91	Exostosis of unspecified site	Inflammation and Pain
727.2	Specific bursitides often of occupational origin	Inflammation and Pain
727.3	Other bursitis disorders	Inflammation and Pain
727.60	Nontraumatic rupture of unspecified tendon	Sprain/Strain/Rupture
727.61	Complete rupture of rotator cuff	Sprain/Strain/Rupture
727.62	Nontraumatic rupture of tendons of biceps (long head)	Sprain/Strain/Rupture
727.63	Nontraumatic rupture of extensor tendons of hand and wrist	Sprain/Strain/Rupture
727.64	Nontraumatic rupture of flexor tendons of hand and wrist	Sprain/Strain/Rupture
727.65	Nontraumatic rupture of quadriceps tendon	Sprain/Strain/Rupture
727.66	Nontraumatic rupture of patellar tendon	Sprain/Strain/Rupture
727.67	Nontraumatic rupture of achilles tendon	Sprain/Strain/Rupture
727.68	Nontraumatic rupture of other tendons of foot and ankle	Sprain/Strain/Rupture
727.69	Nontraumatic rupture of other tendon	Sprain/Strain/Rupture
728.71	Plantar fascial fibromatosis	Inflammation and Pain
728.83	Rupture of muscle, nontraumatic	Sprain/Strain/Rupture
729.1	Myalgia and myositis, unspecified	Inflammation and Pain
729.2	Neuralgia, neuritis, and radiculitis, unspecified	Joint Derangement with Neurological Involvement
733.10	Pathologic fracture, unspecified site	Stress Fracture
733.11	Pathologic fracture of humerus	Stress Fracture
733.12	Pathologic fracture of distal radius and ulna	Stress Fracture
733.13	Pathologic fracture of vertebrae	Stress Fracture
733.14	Pathologic fracture of neck of femur femur	Stress Fracture
733.15	Pathologic fracture of other specified part of femur	Stress Fracture
733.16	Pathologic fracture of tibia or fibula	Stress Fracture

ICD-9- CM Diagnosis Code	Brief Description of ICD-9-CM Diagnosis Code	Injury Type—Injury-related Musculoskeletal Condition Matrix
733.19	Pathologic fracture of other specified site	Stress Fracture
733.93	Stress fracture of tibia or fibia	Stress Fracture
733.94	Stress fracture of metatarsals	Stress Fracture
733.95	Stress fracture of other bone	Stress Fracture
734	Flat foot	Inflammation and Pain

Note:

*Includes all 5th digit subclassifications representing all anatomical sites for the corresponding ICD-9-CM diagnosis.

3-3. NOISE-INDUCED HEARING INJURY SURVEILLANCE IN THE U.S. MILITARY, 2003–2005

A. INTRODUCTION.

(1) The National Institute of Occupational Safety and Health (NIOSH) estimates that approximately 30 million workers in the United States are exposed to hazardous noise with an economic impact of an estimated \$242.4 million per year in disability.⁽¹⁾ According to Veterans Affairs (VA), noise-induced hearing injuries (NIHI) are very costly and are very much a public health problem for former and current Armed Forces Service members. The VA NIHI disability compensation rates are currently running over \$1 billion per year.⁽²⁾

(2) Generally, studies of nonmilitary populations have evaluated NIHI in small, select cohorts of subjects in various industries. Military studies have tended to look at larger populations. For example, in 1975, Walden looked at hearing loss profile prevalence rates among Soldiers in combat arms units and found that 30 percent of combat arms Soldiers had hearing loss profiles of H-2 (mild hearing loss) or worse (severe hearing loss).^(3, 4) A Centers for Disease Control and Prevention study compared hearing loss in Vietnam veterans to nondeployed veterans and found that the Vietnam Service cohort was 40 percent more likely to have high frequency hearing loss than the non-deployed Service cohort.⁽⁵⁾ The most definitive reference on NIHI in the Services after 1945 was published by the Institute of Medicine in 2006.⁽⁶⁾ Data were furnished for this report from audiometric records in the Defense Occupational Environmental Health Readiness System-Hearing Conservation (DOEHRS-HC) database of the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). The report revealed that by 1999 18 percent of military personnel in the Department of Defense (DOD) hearing conservation database showed significant threshold shifts or changes in hearing for the worse.⁽⁷⁾ In 2004, Helfer reported a 21 percent rate of noise induced hearing loss and a 28 percent rate of tinnitus in post-deployment records during the first sixteen months of Operation Iraqi Freedom.⁽⁸⁾

(3) For the U.S. Army, monitoring audiometry is tied to readiness through the Medical Protection System (MEDPROS) Hearing Readiness Module (HRM). Analyses of data from this system suggest that Army audiometry compliance rates are improving. However, since the HRM implementation started in September 2006, it is too early to tell the effect of the process in terms of reducing the prevalence of NIHI for the Army.

(4) The purpose of this section is to: (1) define relevant NIHI-related International Classification of Disease, 9th Revision (ICD-9) codes for surveillance purposes, and to (2) report recent frequencies, distributions, and rates of NIHI for DOD Active Duty military personnel upon which future NIHI monitoring using medical surveillance data can build.

B. METHODS.

(1) For this analysis, the term “noise-induced hearing injury” referred to the result of acoustic overstimulation of the sensory end organ of hearing (cochlea) and associated acoustic energy conduction structures such as the eardrum and middle ear bones (ossicles). Active Duty military personnel, who sought inpatient or outpatient treatment in medical facilities for NIHI, 2003–2005, were identified in the Defense Medical Surveillance System (DMSS) using a list of the ICD-9, Clinical Modification (ICD-9-CM) diagnosis codes selected by the authors (Table 3-3-1). The DMSS data were provided by the Armed Forces Health Surveillance Center (AFHSC) (formerly the Army Medical Surveillance Activity).

TABLE 3-3-1. ICD-9-CM CODES FOR SURVEILLANCE OF NOISE-INDUCED HEARING INJURY

ICD-9-CM code	Diagnosis Description
384.20	Perforation of tympanic membrane, unspecified
384.21	Central perforation of tympanic membrane
384.22	Attic perforation of tympanic membrane
384.23	Other marginal perforation of tympanic me
384.24	Multiple perforations of tympanic membrane
384.25	Total perforation of tympanic membrane
384.81	Atrophic flaccid tympanic membrane
385.23	Discontinuity or dislocation of ear ossic
388.11	Acoustic trauma (explosive) to ear
388.12	Noise-induced hearing loss
388.30	Tinnitus, unspecified
388.31	Subjective tinnitus
388.32	Objective tinnitus
388.43	Impairment of auditory discrimination
389.8	Specified forms of hearing loss nec
389.9	Unspecified hearing loss

(2) Multiple visits for the same diagnosis within 60 days of the initial visit were excluded to reduce the effect of follow-up visits. To capture all NIHI visits and not just those for which the NIHI was the primary reason for the visit, both primary and non-primary NIHI diagnoses were obtained. If there were 60 days or more between the initial visit and the subsequent one, then the latter was counted as a new injury. Quarterly rates were calculated by dividing the number of injuries by the person-time for non-deployed Active Duty personnel at risk during each quarter. Deployed personnel did not contribute to these data, as their medical encounters were not captured by this surveillance system. Rates over time are presented by gender and age. To gain a better sense of subpopulations affected, frequencies and rates by DOD occupational group for 2003-2005 are also presented.

C. RESULTS.

(1) There were 88,285 NIHI visits for Active Duty Service members between January 2003 and December 2005. Figure 3-3-1 shows the quarterly rates for NIHI visits by gender. Men were seen for 88 percent (n=77,938) of the NIHI visits, while women represented 12 percent (n=10,347) of the injury visits. Rates of NIHI visits among female patients followed a similar trend as male patient rates, with the exception of a sharp increase of NIHI visit rates among female patients during the fourth quarter of 2004.

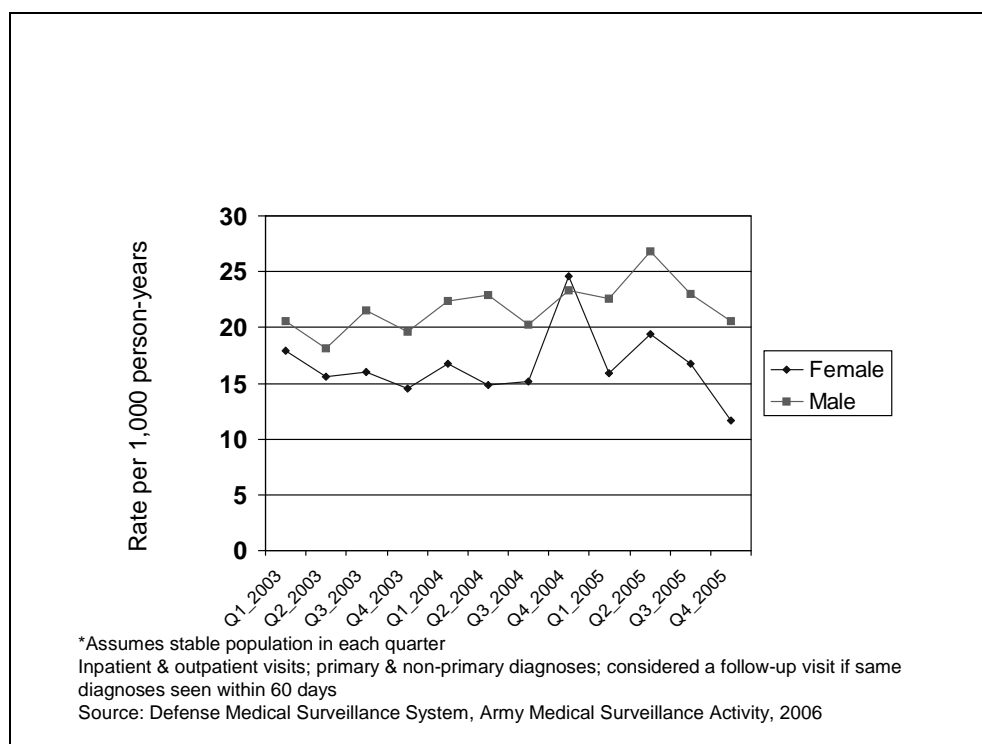


FIGURE 3-3-1. QUARTERLY RATES OF NOISE-INDUCED HEARING LOSS BY GENDER, ACTIVE DUTY MILITARY, 2003–2005*

(2) Figure 3-3-2 shows the quarterly rates for NIHI visits by age group. Consistently, the older the age group, the higher the NIHI visit rate. The NIHI visit rates among Active Duty Service members age 40 and older were over twice as high as the next age group, Active Duty Service members age 35–39. Rates for those 35–39 years of age ran 1.5 times higher than for age groups 30–34 and 25–29. The rate for Service members age 40 and older peaked at nearly 70 (NIHI visits)/1000 person-years in the second quarter of calendar year (CY) 2005. As a comparison, the rate for ages 35–39 peaked also in the second quarter of CY 2005 at a rate of around 35/1000 person-years.

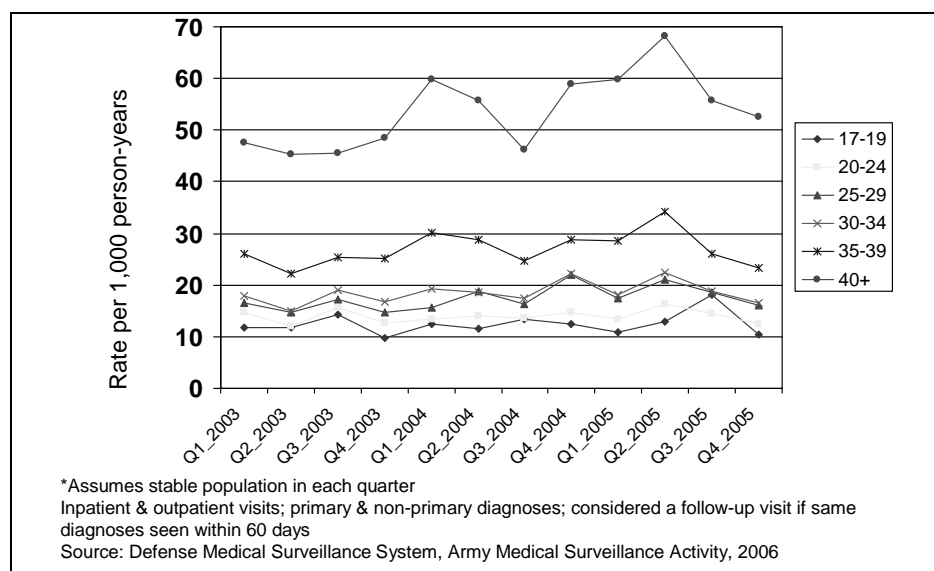


FIGURE 3-3-2. QUARTERLY RATES OF NOISE-INDUCED HEARING LOSS BY AGE, ACTIVE DUTY MILITARY, 2003–2005*

(3) Table 3-3-2 shows frequency of NIHI by DOD occupational group over the period covered, along with rates. Occupational groups such as combat arms (infantry/gun crews) and electrical mechanical equipment repairers had the highest frequencies of NIHI. However, their corresponding rates were lower than other occupational groups. General officers and executives, enlisted trainees, and scientists and professionals had the highest NIHI rates.

TABLE 3-3-2. FREQUENCY AND RATE OF NOISE-INDUCED HEARING LOSS BY DEPARTMENT OF DEFENSE OCCUPATIONAL GROUP, 2003–2005*

DoD Occupational Group (code)	Frequency of noise-induced hearing injury visits	Rate per 1,000 personnel
General officers and executives, not elsewhere classified (21)	225	29.5
Enlisted in training (19)	2,645	14.3
Scientists and professionals (25)	491	12.8
Engineering and maintenance officers (24)	1,169	11.9
Intelligence officers (23)	427	11.8
Crafts workers (17)	1,630	11.5
Administrators (27)	540	11.5
Infantry, gun crews, and seamanship specialists (10)	7,101	11.2
Health care officers (26)	1,198	11.2
Other technical and allied specialists (14)	1,202	11.1
Tactical operations officers (22)	2,574	10.6
Supply, procurement, and allied officers (28)	602	10.2
Electrical/mechanical equipment repairers (16)	6,958	9.3
Health care specialists (13)	2,194	9.0
Service and supply handlers (18)	2,825	8.7
Functional support and administration (15)	4,753	8.2
Communications and intelligence specialists (12)	2,782	7.9
Electronic equipment repairers (11)	2,551	7.9
Officers in training (29)	203	4.9
Total	42,070	9.9

Notes:

* Inpatient and outpatient visits for 2003–2005 combined. Includes primary and non-primary NIHI diagnoses. Follow-up visits for same diagnosis within 60 days were excluded.

Source - AFHSC, DMSS, 2007.

D. DISCUSSION.

(1) The result of gender stratification was consistent with other studies^(11, 12) in that males showed a higher prevalence of NIHI than females. The age stratification also showed results consistent with what was expected, in that increased age showed higher prevalence of NIHI. When looking at the frequencies and rates of NIHI by DOD occupational group, infantry/gun crews (combat arms) and electrical mechanical equipment repairers had higher frequencies but lower than expected rates of NIHI. These occupations were expected to have higher rates of NIHI due to job duties exposing them frequently to firing weapons, operation of noisy equipment, and vehicle noise. This may indicate underreporting of NIHI among combat arms and equipment repair occupations.

(2) The sharp increase of NIHI visit rates among female patients during the fourth quarter of 2004 observed in these data was also seen in an analysis of Army data for the same period.⁽⁹⁾ The ICD-9 codes for severe hearing loss (H-3, H-4 hearing loss profiles) were the source of this

spike. The increase was attributed to a pre-deployment record screening and referrals for audiometry.

(3) The risk exposures to steady state noise that lead to NIHI are well known and predictable for both military and civilian populations. The military exposures include military vehicles, aviation transports, military equipment, as well as tools common to both military and civilian industrial environments. Noise level information on common Army equipment is available on the USACHPPM web site.⁽¹²⁾ In addition, recreational noise exposures are common to both military and civilian populations, including motorcycles, sport shooting, snowmobiles, power tools, and so forth.

(4) Impulse noise damage risks are less predictable. Military members have more of these kinds of exposures in training and now in combat operations due to weapons firing. Exposures to noise from explosives due to combat operations introduce complications such as traumatic brain injury (TBI), dizziness/imbalance outcomes, and other multimodal sensory and sensori-motor central nervous system disorders, along with auditory nervous system disorders associated with TBI. Jordan reported that 12.5 percent of redeploying Army Soldiers from Operation Iraqi Freedom had NIHI.⁽¹³⁾

(5) There are various prevention measures that are effective. The DOD Hearing Conservation Program (HCP) preventive measures include: (1) identification of noise hazards; (2) engineering controls; (3) hearing protectors; (4) monitoring audiometry; (5) health threat briefing/education; (6) command enforcement of safety procedures; and (7) program effectiveness evaluation and monitoring. Active surveillance monitoring audiometry, when adequately enforced, gives preventive medicine better access to check on military personnel hearing protection use and to inform them of risk factors of noise exposure and hearing loss through health threat briefings.

(6) The HCP performance has traditionally been demonstrated by showing a reduced risk of NIHI in noise exposed populations as measured by systems monitoring audiometry data. Since 2001, audiology outcome ICD-9-CM coding guidelines for NIHI have been available to audiologists in the Military Health System (MHS). By early 2003, standard-coding guidelines were more readily available for inputting NIHI codes into MHS medical databases. The NIHI codes from these guidelines provided additional NIHI clinical information to military public health analysts. The NIHI ICD-9 data quality has significantly improved since 2003. Military public health analysts can also use passive surveillance of these ICD-9 data from DMSS for additional evaluation of HCP performance.

(7) The strengths of this analysis were the following: (1) the data received from DMSS consisted of all medical encounters of Active Duty personnel; (2) all medical encounters were subject to standardized and routine recordkeeping and coding; (3) the data collected came from a large patient population (approximately 1.3 million Active Duty personnel have access to MHS

care); and (4) the data-captured care received both within and outside the MHS (purchased care). A final strength of this study was having a study population (Active Duty military personnel) that had equal access to care.

(8) The limitations of the analysis included: (1) data on the troops deployed and receiving care in the theater of operations were not available in DMSS; (2) Guard and Reserve troop data are not included in the present study, so prevalence of NIHI in these populations is unknown and the cost and reduced readiness burdens of NIHI in the Guard and Reserve are likewise unknown; (3) accuracy of the NIHI diagnoses; (4) where the diagnoses were correct, the person entering the ICD-9-CM code(s) may have not entered the most specific or accurate code; (5) the aggregation of NIHI across all U.S. Services probably affects the prevalence reported, particularly if the rates among the services are varied on the basis of different exposures and the “safety cultures” of the individual services; and (6) the aggregation of NIHI ICD-9-CM codes blurs the distinction of different clinical outcomes tied to different exposures (such as, steady noise vs. impulse noise of weapons firing or exposure to explosives during war operations).

(9) Initially, ICD-9-CM codes for dizziness and imbalance were included because of the anatomical proximity of the hearing and balance systems, with injury susceptibility to both from loud noise and because of the observation of the co-occurrence of balance disorders with NIHI in redeploying soldiers with blast trauma. The incidence of balance disorders and their relation to clinical pathology and the fact that they are only marginally related to redeployment cycles were reasons they were not included in this report, but they bear further investigation separately.

E. CONCLUSIONS AND RECOMMENDATIONS.

(1) Key findings of the current study included: (1) NIHI losses in the U.S. military are high, with NIHI rates between 15 and 22/1000 person-years; (2) rates are much higher in males than females; (3) rates are much higher among Service members 40 years of age and older; (4) deployment cycles and increased operational tempo between 2003–2005 significantly impacted the incidence of NIHI; and (5) emphasis on ICD-9-CM coding standards for NIHI over the past few years seem to be paying off in delivering better quality data for reporting.

(2) There are many recommendations to improve NIHI surveillance in the DOD: (1) emphasize improved reporting of NIHI by encouraging precision coding of the ICD-9-CM data into healthcare databases and encouraging better annotation of hearing profiles in medical records; (2) use DMSS as the primary data source for monitoring NIHI in order to compare with other injury types (ICD-9-CM codes) in the DOD-level reports; (3) instruct public health analysts to make denominator adjustments to “person-year” to exclude time lost to follow up (either from deployment, separation from service, retirement, demobilization, or death) and thereby, making for more accurate reporting; (4) perform separate surveillance processes for Active Duty and Guard/Reserve Service members; (5) report NIHI by CY for better comparison

with DMSS data for other injuries; (6) report injury rates stratified by gender and age, allowing health promotion and education efforts to target specific age/gender groups; (7) report injury rates stratified by occupation types, thereby, helping to develop health promotion and education materials targeted at specific occupational groups; (8) conduct post-deployment analyses and reporting separately from general DOD NIHI rates; (9) conduct post-deployment analyses and reporting for individual Services based on different combat exposures; (10) conduct post-deployment analyses stratified by pre-, post- and non-deployment categories and verified by intersection with accurate personnel data as to deployment status at the time of medical encounters; and (11) report different categories or symptoms of NIHI (such as, tinnitus, acoustic trauma, sensory hearing loss due to steady noise exposure) individually rather than aggregated for DOD reports.

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3-4. EYE INJURY SURVEILLANCE IN THE U.S. MILITARY, 1996–2005

A. INTRODUCTION.

(1) A summary of U.S. survey data on hospitalizations and ambulatory care estimated that nearly 2 million individuals experienced an eye injury requiring treatment in an emergency department, inpatient or outpatient facility, or private physician's office in 2001, for a rate of 7.0 per 1,000 persons.⁽¹⁾ A second study performed by the same authors using the same data sources analyzed the trend in United States eye injuries from 1992–2001 and found an estimated 3 million individuals experienced an eye injury annually. In addition, they estimated an overall injury rate ranging from 8.2 to 13.0 per 1,000 persons and an overall downward trend with 2001 having the lowest rate.⁽²⁾ Both studies used a distinct set of International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) 800 and 900 series eye injury codes to identify patients with eye injuries.

(2) In the military, several studies have provided a range of rates for eye injuries. A study of Department of Defense (DOD) injuries using safety center data from fiscal years (FY) 1988–1998 showed a range of eye injury incidence from 44.0 per 100,000 Service members in FY 1988 to 8.0 per 100,000 Service members in FY 1998.⁽³⁾ Two additional studies identified eye injuries using code sets similar to that used in the civilian studies noted above. The first study looked at work-related U.S. Army Active Duty eye injuries resulting in hospitalization over the period 1980–1997 and found an overall rate for hospitalized eye injuries of 27.6 per 100,000 person-years.⁽⁴⁾ The second study looked at all U.S. Armed Forces Active Duty members during 1998 who were either hospitalized or seen on an ambulatory basis for an eye injury and found a rate of 17.0 per 100,000 person-years for hospitalized injuries and 983.0 per 100,000 person-years for ambulatory injuries.⁽⁵⁾ While the previous studies looked at the entire U.S. Armed Forces or U.S. Army population retrospectively, a study done in 1989 looked at medical records to identify Active Duty U.S. Army eye injuries treated at inpatient, outpatient, and unit-based treatment sites at 3 installations over a 5-month period and determined an overall eye injury rate of 1,420.0 per 100,000 person-years.⁽⁶⁾

(3) The purpose of this paper is to report frequencies, distributions, and rates of eye injuries among Active Duty military personnel for 1996–2005; present causes of eye injury hospitalizations; and recommend approaches to improving surveillance, research, and prevention of eye injuries.

B. METHODS. For this study, the term “eye” referred to hard and soft tissues of the orbital cavity and/or the adjacent and associated structures. Active Duty military personnel, who sought inpatient or outpatient treatment in medical facilities for one or more injuries of the eye, 1996–2005, were identified in the Defense Medical Surveillance System (DMSS) using a list of the ICD-9-CM diagnosis codes selected by the authors (Table 3-4-1). DMSS data were obtained from the Armed Forces Health Surveillance Center (formerly, Army Medical Surveillance

Activity). In order to provide a more comprehensive view of the eye injury problem, eye injury-related ICD-9 codes beyond the traditional 800-999 ICD-9 injury code set were included. To ensure capture, all eye injury visits, both primary and nonprimary eye injury diagnoses, were obtained. Multiple visits for the same eye injury diagnosis within 60 days of the initial visit were excluded to enhance capture of incident injuries only. Rates were calculated by dividing the number of injuries by the person-years of the DOD Active Duty population at risk and are presented by gender and age group. Cause of injury, routinely coded for hospitalizations, is coded using the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) No. 2050⁽⁷⁾. For calendar year (CY) 2005, the top ten specific eye injury ICD-9-CM codes and a ranking of causes of eye injury for hospitalizations are presented.

TABLE 3-4-1. ICD-9-CM CODES USED TO IDENTIFY EYE INJURIES

ICD-9-CM Code	Code Description
360.3	Hypotony, primary (posttraumatic)
361	Retinal detachment with retinal defect unspecified
362.81	Hemorrhage, retinal
363.31	Solar retinopathy
363.61	Chorioidal hemorrhage, unspecified
363.62	Chorioidal rupture, expulsive
363.63	Chorioidal rupture
363.7	Chorioidal detachment, unspecified
363.71	Chorioidal detachment, serous (not central serous)
363.72	Chorioidal detachment, hemorrhagic
364.41	Hyphema/hemorrhage, anterior chamber (aqueous)
364.76	Iridodialysis
364.8	Iris prolapse, unspecified
365.65	Glaucoma, trauma (ocular), NEC
366.2	Cataract traumatic, unspecified
366.22	Cataract, total, traumatic
366.46	Cataract traumatic, radiation & other physical influences
369.01	Blindness, total
369.03	Blindness, near total/total
370.03	Ulcer, central corneal
370.04	Ulcer, hypopyon
370.06	Ulcer, corneal perforation
370.2	Keratitis, superficial
370.21	Keratitis, punctate
370.24	Keratitis, actinic/welders'/photokeratitis
370.34	Keratoconjunctivitis, due to exposure
371.0	Corneal opacity unspecified
371.22	Edema, secondary to injury
371.24	Corneal edema secondary to contact lens wear
371.82	Corneal disorder/injury due to contact lens
372.05	Conjunctivitis
372.39	Conjunctivitis, traumatic not elsewhere classified
372.72	Hemorrhage (ecchymosis), conjunctiva/subconjunctival

TABLE 3-4-1. ICD-9-CM CODES USED TO IDENTIFY EYE INJURIES (CONTINUED)

ICD-9-CM Code	Code Description
374.22	Lagophthalmos, mechanical
374.33	Ptosis, mechanical
374.81	Hemorrhage, eyelid
374.86	Foreign body, eyelid retained
376.3	Globe, displacement (lateral)
376.32	Orbital hemorrhage
376.36	Lateral displacement of globe
376.47	Orbit deformity secondary to trauma/surgery
376.52	Enophthalmos, secondary to trauma/surgery
379.23	Hemorrhage, vitreous
379.32	Subluxation of lens
802.6	Blowout fracture floor of orbit, closed
802.7	Blowout fracture floor of orbit, open
802.8	Fracture not otherwise specified/other than roof or floor
870.0	Laceration/open wound, eyelid & periocular area
870.1	Laceration/open wound, eyelid full thickness
870.2	Laceration/open wound, eyelid involving lacrimal passages
870.3	Open wound, orbit (penetrating) without foreign body
870.4	Open wound, orbit (penetrating) with foreign body
870.8	Laceration/open wound, ocular adnexa other specified
870.9	Laceration/open wound, ocular adnexa, unspecified
871.0	Laceration/open wound, eyeball without prolapse
871.1	Laceration/open wound, eyeball with prolapse of intraocular tissue
871.2	Rupture with partial loss of intraocular tissue eye
871.3	Avulsion/traumatic enucleation
871.4	Laceration, unspecified
871.5	Foreign body, intraocular penetrating (magnetic)
871.6	Foreign body, penetration of eyeball with nonmagnetic
871.7	Open wound, eyeball (penetrating)
871.9	Open wound, (wound unspecified)
918.0	Abrasion, periocular area
918.1	Abrasion/laceration, cornea
918.2	Abrasion, conjunctival
918.9	Abrasion, eye, NOS superficial injury to eye
921.0	Contusion/hematoma, eye & adenexa (black eye NOS)
921.1	Contusion/hematoma, periocular
921.2	Contusion, orbital tissue
921.3	Contusion/hematoma, cornea/eyeball
921.9	Hematoma, traumatic, adnexa eye NOS
925.1	Crushing injury
930.0	Foreign body, cornea

TABLE 3-4-1. ICD-9-CM CODES USED TO IDENTIFY EYE INJURIES (CONTINUED)

ICD-9-CM code	Code Description
930.1	Foreign body, conjunctiva
930.2	Foreign body, lacrimal punctum (external)
930.8	Foreign body, external eye through orifice other and combined sites
930.9	Foreign body, external eye unspecified
940.0	Burn, chemical burn of eyelids & periocular area
940.1	Burn, other burn of eyelids & periocular area
940.2	Burn, alkaline chemical burn, cornea & conjunctiva
940.3	Burn, acid chemical burn of cornea & conjunctival
940.4	Burn, other burn of cornea & conjunctival
940.5	Burn, with resulting rupture & destruction of eyeball
940.9	Burn, unspecified burn of eye & adnexa
950.0	Injury, optic nerve & pathways
950.9	Injury, optic nerve & pathways, unspecified traumatic blindness
951.0	Injury oculomotor (3 rd cranial nerve)
951.1	Injury trochlear (4 th cranial nerve)
951.2	Injury trigeminal (5 th cranial nerve)
951.3	Injury abducens (6 th cranial nerve)
951.4	Facial nerve (7 th) injury

C. RESULTS.

(1) Figure 3-4-1 shows the rates of eye injuries by gender. The injury rates for females are consistently higher than for males. The injury rate for females rose from 1996–2005, ranging from 2.5 injuries/1000 person-years in 1996, to just over 26.0 injuries/1000 person-years in 2005. The injury rate for males rose from 1996–2005, from 2.5 injuries/1000 person-years in 1996 to just a little over 21.0 injuries/1000 person-years in 2005. The rate of injuries for females and males both peaked in 2004 at approximately 26.5 fractures/1000 person-years for females and 23.0 injuries/1000 person-years for males.

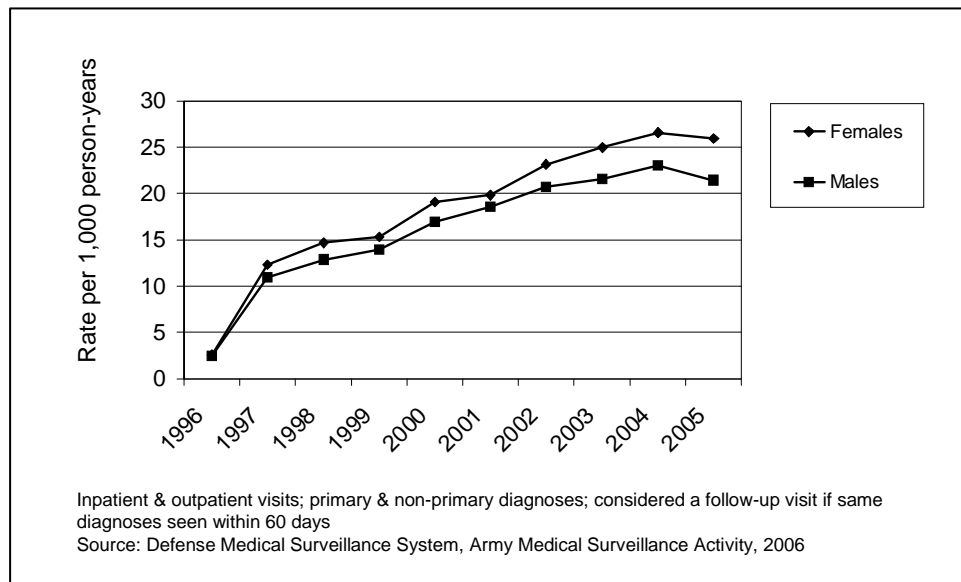


FIGURE 3-4-1. RATES OF EYE INJURIES BY GENDER, ACTIVE DUTY MILITARY, 1996–2005

(2) Figure 3-4-2 shows the rates of eye injuries by age group. Overall, the injury rate patterns were relatively similar across age groups. Also, the differences between the age groups were small to moderate. However, age group 17–19 had the lowest injury rates for the entire study period. The age group 40+ had the highest injury rates for years 1996–1997 and 2001–2005. Also, age group 40+ had the second highest injury rates for years 1998–2000. Age group 20–24 had the highest injury rates for 1998–2000 and then dropped to the second lowest age group by 2005. By 2003–2005, the age group 35–39 tended to be the second highest age group. From 1996–2005, all age groups experienced a rise in injury rates, with 2004 being their peak year. The injury rates for 2004 ranged from around 21.0 injuries/1000 person-years (for age group 17–19) to around 26.0 injuries/1000 person-years (for age group 40+). All age groups had declines in injury rates in 2005.

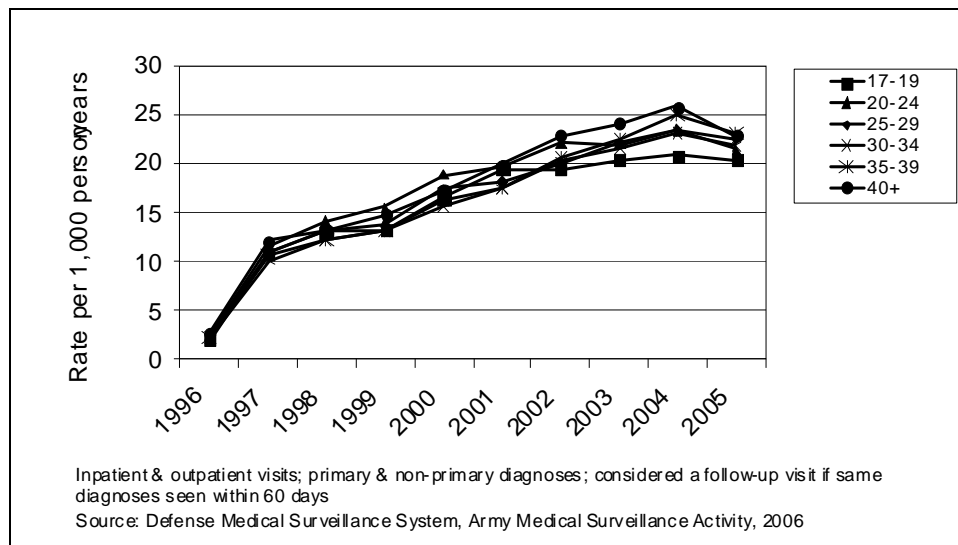


FIGURE 3-4-2. RATES OF EYE INJURIES BY AGE GROUP, ACTIVE DUTY MILITARY, 1996–2005

(3) The leading causes of hospitalization due to eye injury among DOD Active Duty personnel in 2005 are shown in Figure 3-4-3. The falls and miscellaneous category (38 percent) and guns/explosives (20 percent) were the leading causes of eye injuries requiring hospitalization. They were both nearly twice as common as the next leading cause, enemy actions during war (16 percent). Sports was the fourth leading cause of eye injury hospitalizations (10 percent); followed by machinery (9 percent), land accident (4 percent), medical and surgical complications (2 percent), and air accidents (0.5 percent).

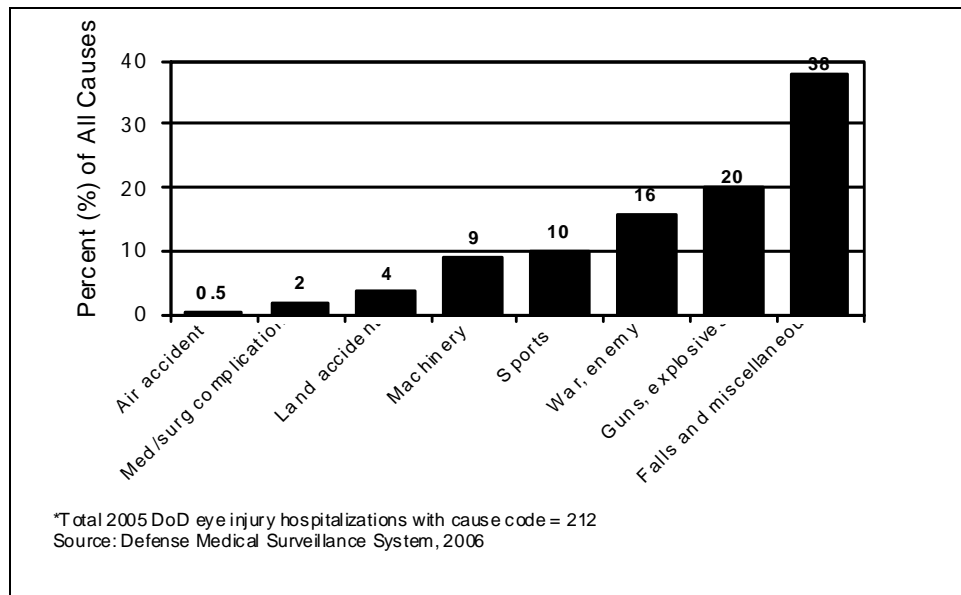


FIGURE 3-4-3. CAUSES OF EYE INJURY HOSPITALIZATIONS, ACTIVE DUTY MILITARY, 2005

(4) Figure 3-4-4 shows the distribution of eye injury (hospital and outpatient) visits by ICD-9-CM diagnosis code description, in 2005, of Active Duty military personnel. The most common diagnoses were abrasion/superficial lacerations of the cornea. Corneal abrasions and lacerations accounted for 26.7 percent of all patient visits for eye injuries and an incidence rate of 588.5 per 100,000 personnel. Corneal abrasions were over three times as common as the next leading diagnoses, punctate keratitis, which accounted for 7.6 percent, at a rate of 166.6 per 100,000. These diagnoses were followed by other conjunctivitis (6.3 percent, 139.5/100,000), conjunctival hemorrhage (5.7 percent, 125.1/100,000), and corneal foreign bodies (4.9 percent, 107.3/ 100,000).

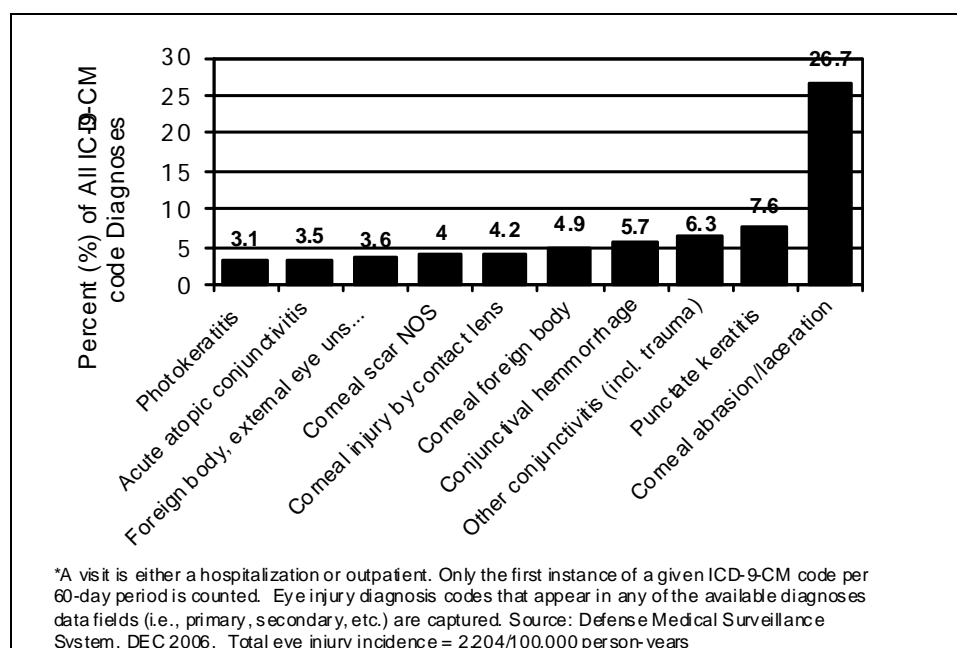


FIGURE 3-4-4. TOP TEN MOST FREQUENT DIAGNOSES OF EYE INJURY VISITS,*
ACTIVE DUTY MILITARY, 2005

D. DISCUSSION.

(1) This analysis presents an overall picture of eye injuries in the U.S. Active Duty military population, providing baseline eye injury rates upon which future surveillance efforts can build. Overall, eye injury rates among U.S. Active Duty military personnel increased from 1996 to 2005. Some, but not all, of the rise in rates may be attributable to (across DOD) changes in clinic data reporting, improvements in clinic data ascertainment/collection, and enhanced capture of care received in non-military health care settings during this time period.

(2) Among Active Duty military personnel, females consistently had higher eye injury rates than males. The only other studies that present a combined analysis of inpatient and outpatient data are the civilian studies by McGwin et al.^(1, 2) Both studies found males had a higher rate of eye injury than females. The study by Andreotti et al.⁽⁵⁾ found that females had a slightly higher rate of eye injury than males for ambulatory injuries. Since the majority of encounters in our study were for outpatient visits, this tends to confirm our data. Additional exploratory analysis indicated that higher rates were seen among females for injuries typically associated with contact lens wear and dry eye (e.g., corneal disorder due to contact lens, non-infectious conjunctivitis, superficial corneal irritation, and corneal abrasion). Three out of four of these diagnoses are found in ICD-9-CM Chapter 6 (Diseases of the Nervous System and Sense Organs). Use of the additional Chapter 6 codes likely explain the higher female rates seen in this analysis. The other studies cited here had either too small a population⁽⁶⁾ or looked specifically at unique populations^(3, 4) and do not invite direct comparison.

(3) Looking at age, one might expect to observe lower eye injury rates among older personnel due to greater work experience and more time spent on lower-risk, managerial activities. However, this study found that Service members under age 20 had the lowest rate of eye injuries and those age 40 and older tended to have the highest rates. As noted with gender, the only other studies that present a combined analysis of inpatient and outpatient data are the civilian studies by McGwin et al.^(1, 2) Both studies found the 20–39 year old age group consistently had the highest rate of eye injury. The study by Andreotti et al.⁽⁵⁾ noted that the 17–24 age group had the highest eye injury rate in 1998 and is in agreement with the data presented in this study. A potential factor influencing the rates presented in this study may be the increased number of older active duty military personnel engaging in training and operational activities in support of the war. In addition, changes in recruitment policies have expanded age limitations allowing in new recruits at an older age. And as with gender, the use of the additional codes to identify eye injuries may impact this finding and provides an avenue for further analysis.

(4) In this study, for CY 2005, falls were found to be the leading cause of inpatient eye injuries for military personnel followed by guns and explosives, war (enemy), machinery and tools, and land (motor vehicle) accidents. In the study by Andreotti et al.⁽⁵⁾, motor vehicle (land) accidents and fights were the top causes of eye injuries followed by machinery and tools, athletics, and falls. Both of these studies used the NATO STANAG 2050 injury cause categories⁽⁷⁾ to define causes of inpatient eye injuries. However, the Andreotti study separated fights from the falls and miscellaneous injury cause category, while in this study, fights were not separated out. Future analyses should consider fighting separately. The relative increase in guns and explosives and war (enemy) are likely attributable to the influence of wartime activities in Iraq and Afghanistan and training for these activities. Reported causes represent only the causes of the most severe (hospitalized) eye injuries, however. Given that the majority of eye injury visits (approximately 95–99 percent) are treated on an outpatient basis, cause coding of outpatient data is needed to gain a better understanding of causes of all eye injuries.

(5) In looking at the diagnoses of eye injuries that resulted in a hospitalization or an outpatient visit, corneal abrasions/superficial lacerations were by far the most common diagnoses. Three previously cited studies^(1, 2, 5) present data on the type of injury, and all three rank superficial injury to the eye as the most common injury, followed by foreign bodies of the external eye and contusions. These studies present their outcomes by code group rather than specific codes and as mentioned previously do not include the additional 300 series codes that make up the second, third, and fourth most common injury codes found in this study.

(6) The strengths of this study were the following: (1) the data collected were on all inpatient and outpatient encounters of Active Duty personnel⁽⁸⁾ including optometry visits (not reported in the civilian studies cited)^(1, 2); (2) all medical encounters were subject to standardized and routine recordkeeping; (3) the data collected came from a large patient population (approximately 1.3 million Active Duty personnel have access to military healthcare system);

and (4) the data captured care received both within the military health system and outside the military health system. A final strength of this study was having a study population (Active Duty military personnel) that had equal access to care.

(7) Weaknesses and limitations to this study included that the surveillance system does not capture treatment for very minor injuries received at battalion aid stations or medical care received in theaters of operation such as Iraq and Afghanistan that was not evacuated out of country. The lack of this data may lead to an underestimation of rates. In addition, as mentioned previously, DMSS does not capture causes of eye injuries treated in outpatient settings, where an estimated 95–99 percent of all eye injuries are treated. Such information is essential to properly discern a work-related injury from an off-duty injury when planning interventions. The DMSS also does not capture the presence or absence of eye protection at the time of injury for either inpatient or outpatient care. Lack of this data limits the ability to determine the impact of preventive strategies involving the use of safety eyewear.

(8) Finally, the list of ICD-9-CM diagnosis codes selected to identify eye injuries in this study differs from those used in previous work,^(1, 2, 4, 5) in that it includes forty-five 360–370 series ICD-9-CM codes in addition to forty-eight 800–900 series ICD-9-CM codes. Prior studies used a code set that included only 800–900 series injury codes that applied to the eye. Andreotti et al., acknowledge in their commentary that “...diagnosis associated with, but not specific for, eye injuries were not included (e.g., hyphema, iritis, retinal detachment, photokeratitis, and corneal edema)” and note that this (in addition to other factors) leads to an underestimation of eye injury rates in their study. Since the purpose of this study was to provide a more comprehensive view of eye injuries among U.S. military personnel, the authors of this study consulted military optometrists who reviewed the ICD-9 code set and selected diagnoses codes that, in their opinion, had a greater than 50 percent chance of being the result of an eye injury. The inclusion of these additional codes, which include common co-morbidities often seen with eye injuries, may lead to some overestimation in the rates of eye injury in the military and may represent a high-end estimation for this population. The inclusion of these additional codes may result in a high-end estimation of rates for this population; however, it was felt to be necessary and appropriate to include these codes in order to ensure comprehensive eye injury surveillance. Fine tuning this expanded code list is another avenue for further study.

E. CONCLUSIONS AND RECOMMENDATIONS.

(1) The key findings of this study concerning eye injuries were the following: (1) DOD Active Duty females had a higher eye injury rate, 1996–2005, than males; (2) differences in rates of eye injuries among age groups, 1996–2005, were moderate overall with Active Duty military personnel under age 20 having the lowest rates of eye injuries while Active Duty personnel over age 40 had the highest rates of eye injuries; (3) ‘falls and miscellaneous’ and ‘guns/explosives’ were the leading causes of eye injury hospitalizations in 2005; (4) corneal

abrasions were the most common diagnoses of eye injury outpatient visits and hospitalizations in 2005.

(2) As stated earlier, surveillance systems used by DOD for tracking eye injuries, such as DMSS, lack the ability to discern cause of injury for eye injuries treated in outpatient settings. Since outpatient eye injuries represent 95–99 percent of total eye injuries the importance in this is that identifying duty-related or recreation-related injuries is paramount in designing effective intervention strategies. These systems also do not discern whether or not eye protection was used at the time of injury. Such data is critical in determining the impact of safety eyewear as a preventive intervention.

(3) Conducting injury surveillance using systems like the DMSS are dependant on the codes used to identify the injuries. Previous studies have limited their codes to the discrete 800–900 eye injury codes while we used an expanded code set aimed at capturing additional eye injuries where an 800–900 code may not have been used. One method likely underestimates the problem while our approach admittedly may overestimate it. One potential benefit of enhanced cause coding for outpatient injury visits would be the ability to more accurately identify an injury coded with a noninjury code based on the presence of a cause code.

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3-5. ORAL-MAXILLOFACIAL INJURY SURVEILLANCE IN THE U.S. MILITARY, 1996–2005

A. INTRODUCTION.

(1) Injuries are a major public health problem, outranking cancer and heart disease as a leading cause of death in some age groups of the population. Cranial injuries in particular are a leading cause of mortality and morbidity.⁽¹⁾ According to the Surgeon General's 2000 report on oral health in America, "Oral-facial injuries can bring disfigurement and dysfunction, greatly diminishing quality of life and contributing to social and economic burdens."⁽¹⁾

(2) According to the National Institute of Dental and Craniofacial Research, there are 20 million visits to emergency departments for craniofacial injuries every year. Also, annually there are close to 6 million oral-facial injuries treated by dentists in private offices.⁽²⁾ Among males and females, 10.1 percent and 12.2 percent of emergency room visits are due to craniofacial injuries.⁽³⁾ However, in 1993–1994, males account for less than half the population; but 58.3 percent of craniofacial injuries. In that same time period, persons 24 years or younger accounted for only 36.3 percent of the population but made up almost 48 percent of craniofacial injury visits.⁽²⁾ Persons 15–24 years of age have 11.8 percent of emergency room visits due to craniofacial injuries, as opposed to 7.4 percent of ages 25–44 and 7.1 percent of ages 45–64.⁽³⁾ There are differences in rates of emergency room visits for craniofacial injuries among demographic groups. Males had higher rates than females except among older adults. The rates of injury were higher for younger adults than for those in the middle years.⁽¹⁾

(3) In the military, there have been studies of injury to the head and neck area. In 1975, a study of accidental injury in Navy recruits by Hoeffler reported a head and neck injury rate of 68/10,000/year.⁽⁴⁾ There have been some studies of injury to the oral-facial area. Jeffcott studied maxillofacial injuries among military personnel in World War II. He found (primarily nonbattle) maxillofacial injury rates of 6.0–12.0/10,000 troops/year for military personnel stationed in the continental United States.⁽⁵⁾ A study of Army personnel by Katz reported an "accidental dentofacial"¹ injury rate of 37.7 /10,000/year. Katz also showed that males were much more prone to injury than females and that over 90 percent of "dentofacial" injury occurred prior to age 25.⁽⁶⁾ Mitchener did a study of air medical evacuations (MEDEVACs) of Soldiers out of Operations Enduring Freedom and Iraqi Freedom due to oral-facial conditions in which he found an oral-facial nonbattle injury MEDEVAC rate of 2.5/10,000/year and an oral-facial battle injury MEDEVAC rate of 4.2/10,000/year.⁽⁷⁾

(4) In summary, it is suggested that the burden of craniofacial and oral-facial injuries in civilian populations is well defined. However, due to the lack of epidemiologic studies, the size and the scope of the problem is not clearly understood. Also, the size and scope of craniofacial and oral-facial injuries in the military is not well understood. The purpose of this study is to define relevant oral-facial injury related International Classification of Disease, 9th Revision

¹ "Dentofacial" means pertaining to the teeth, jaws, intraoral soft tissues, perioral soft tissues, and facial bones.

(ICD-9) codes; report Department of Defense (DOD) frequencies, distributions, and rates of oral-facial injuries and causes; and recommend approaches to improving surveillance, research, and prevention where possible.

B. METHODS.

(1) For this study, the term “oral-facial” referred to hard and soft tissues of the oral cavity, maxillofacial area, and/or the adjacent and associated structures⁽⁸⁾ such as the orbital floor (formed in part by the maxilla) and parts of the neck closest to the mandible. Adjacent structures such as the ear, the eye, and the nose were not included. Active Duty military personnel, who sought inpatient or outpatient treatment in medical facilities for one or more injuries of the oral-facial region, 1996–2005, were identified in the Defense Medical Surveillance System (DMSS) using a list of ICD-9, Clinical Modification (ICD-9-CM) diagnosis codes selected by this author. The ICD-9-CM diagnosis codes were further divided into two categories: (1) oral-facial wounds, and (2) oral-facial fractures (Table 3-5-1). The DMSS data were obtained from the Armed Forces Health Surveillance Center (formerly, Army Medical Surveillance Activity).

TABLE 3-5-1. ICD-9-CM CODES USED TO IDENTIFY DENTAL, ORAL, AND MAXILLOFACIAL INJURIES

ICD-9 9 th Revision (2002) CM Codes	
Fractures	
802.20-802.29	Mandible fracture, closed
802.30-802.39	Mandible fracture, open
802.4 & .5	Malar & Maxillary bones, closed & open
802.6 & .7	Orbital Floor (blow-out) , closed & open
802.8 & .9	Other Facial bones, closed & open (Alveolus, Palate)
830.0 & .1	Dislocation of Jaw, closed & open
848.1	Sprain or Strain of Temporomandibular Joint Disorder (or TMJ)
Wounds	
873.40	Open wound of the Face, Unspecified site, Not Complicated
873.41	Open wound of the Face, Cheek , Not Complicated
873.43	Open Wound of Lip
873.44	Open Wound of Jaw
873.50	Open wound of the Face, Unspecified site, Complicated
873.51	Open wound of the Face, Cheek , Complicated
873.53	Open Wound of Lip, Complicated
873.54	Open Wound of Jaw, Complicated
873.6	Open Wound of Internal Structures of mouth, fractured tooth
873.7	Open Wound of Internal Structures of mouth, fractured tooth, Complicated
905.0	Late Effect of Fracture of Facial Bones (including maxilla and mandible)
906.0	Late Effect of Open Wound of Head (including oral region)
906.5	Late Effect of Burn to Face, Head Area (including oral region)
910.0–910.9	Superficial Injury of Face, Neck (including oral region, lip, gum, etc.)

TABLE 3-5-1. ICD-9-CM CODES USED TO IDENTIFY DENTAL, ORAL, ANDR MAXILLOFACIAL INJURIES (CONTINUED)

ICD-9 9 th Revision (2002) CM Codes	
Wounds (continued)	
920	Contusion of Face, etc. (Includes Lip & Gum)
935.0	Foreign Body in Mouth
941.00	Burn of Face and Head, Unspecified Site, Unspecified Degree
941.03	Burn of Lip-unspecified degree
941.10	Burn of Face and Head, Unspecified Site (first degree)
941.13	Burn of Lip-erythema (first degree)
941.20	Burn of Face and Head, Unspecified Site (second degree)
941.23	Burn of Lip-blisters, epidermal loss (second degree)
941.30	Burn of Face and Head, Unspecified Site (third degree NOS)
941.33	Burn of Lip-full-thickness skin loss (third degree NOS)
941.40	Burn of Face and Head, Unspecified Site-Deep necrosis of underlying tissues (deep third degree) without mention of loss of a body part
941.43	Burn of Lip-Deep necrosis of underlying tissues (deep third degree) without mention of loss of a body part
941.50	Burn of Face and Head, Unspecified Site- Deep necrosis of underlying tissues (deep third degree) with loss of a body part
941.53	Burn of Lip- Deep necrosis of underlying tissues (deep third degree) with loss of a body part
947.0	Burn of Mouth & Pharynx (gum & tongue)
951.2	Injury to Trigeminal Nerve
959.09	Injury to Face (lip & mouth)
Injury codes in Diseases of Oral Cavity, Salivary Glands, and Jaws	
525.11	Loss of teeth due to trauma
528.9	Other and unspecified diseases of the oral soft tissues-includes cheek & lip biting & (traumatic) ulcers

(2) Multiple visits for the same oral-facial injury diagnosis within 60 days of the initial visit were excluded to reduce the effect of follow-up visits. To capture all oral-facial injury visits and not just those for which the oral-facial injury was the primary reason for the visit, both primary and nonprimary oral-facial injury diagnoses were obtained from the DMSS. Rates were calculated by dividing the number of injuries by the person-years of the DOD Active Duty military population at risk and are presented by gender and age group. For calendar year (CY) 2005, the distribution of the leading causes of oral-facial injury hospitalizations are presented.

C. RESULTS.

(1) There tended to be a substantial increase in wounds and fractures in 2000 compared to previous years. Yet, this was prior to the events of September 11, 2001 and our subsequent involvements in Afghanistan and Iraq. The dramatic rise in fracture and wound rates by gender and age from 1998–2000 were likely due to (across DOD) changes in clinic data reporting and improvements in clinic data ascertainment/collection. In addition, there were advances in computer capabilities from 1996–2000. As a result, further discussion focuses on rates from 2000 to 2005.

(2) Figure 3-5-1 shows the rates of oral-maxillofacial fractures by gender. The fracture rates for males are consistently higher than for females. The fracture rate for males from 2000–2005 ranges from just a little over 1.2 fractures/1000 person-years (in 2000) to 1.5 fractures/1000 person-years (in 2004), with rates in other years approximately 1.4 fractures/1000 person years. The rate of fracture for females peaked in 2001 at 1.0 fractures/1000 person-years. The rate then stayed steady from 2002 to 2004 at a rate of 0.8-0.9 fractures/1000 person-years and dropped to 0.7 fractures/1000 person-years in 2005.

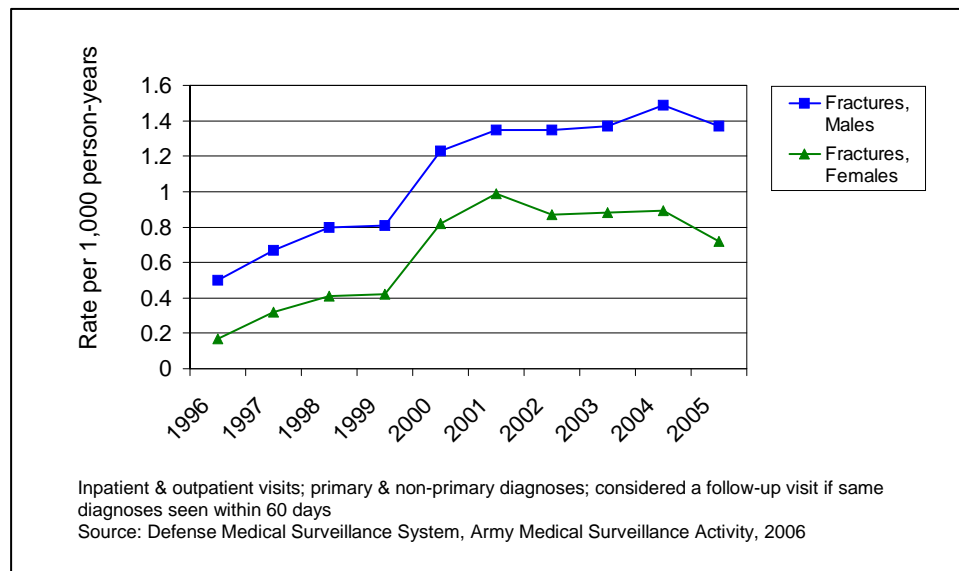


FIGURE 3-5-1. RATES OF ORAL-MAXILLOFACIAL FRACTURES BY GENDER, ACTIVE DUTY MILITARY, 1996–2005

(3) Figure 3-5-2 shows the rates of oral-maxillofacial wounds by gender. The wound rates for both genders rise from 2000 to 2002, then level off from 2002 to 2004, and dip in 2005. Unlike fractures, wound rates for males and females were similar over time.

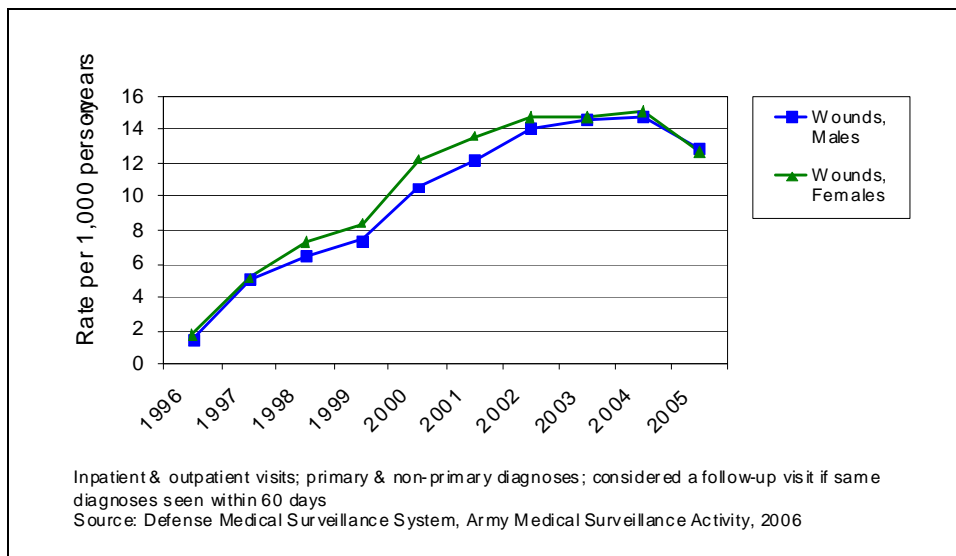


FIGURE 3-5-2. RATES OF ORAL-MAXILLOFACIAL WOUNDS BY GENDER, ACTIVE DUTY MILITARY, 1996–2005

(4) Figure 3-5-3 shows the rates of oral-maxillofacial fractures by age group. The fracture rates among Active Duty military personnel, ages 17–19 and 20–24, are consistently higher than for all other age groups. From 2000–2005, the fracture rates for these age groups were consistently above 1.5 fractures/1000 person years. In 2001–2004, both age groups stayed steady at around 2.0 fractures/1000 person years. In 2005, the rates for both age groups dropped; with a more noticeable drop in the 17–19 age group. Ages 25–29 stayed fairly steady from 2000–2005 at around 1.1–1.2 fractures/1000 person years. All other age groups had relatively stable rates well below 1.0 fractures/1000 person years for 2000–2005. Each successive age group had a slightly lower rate than the previous age group.

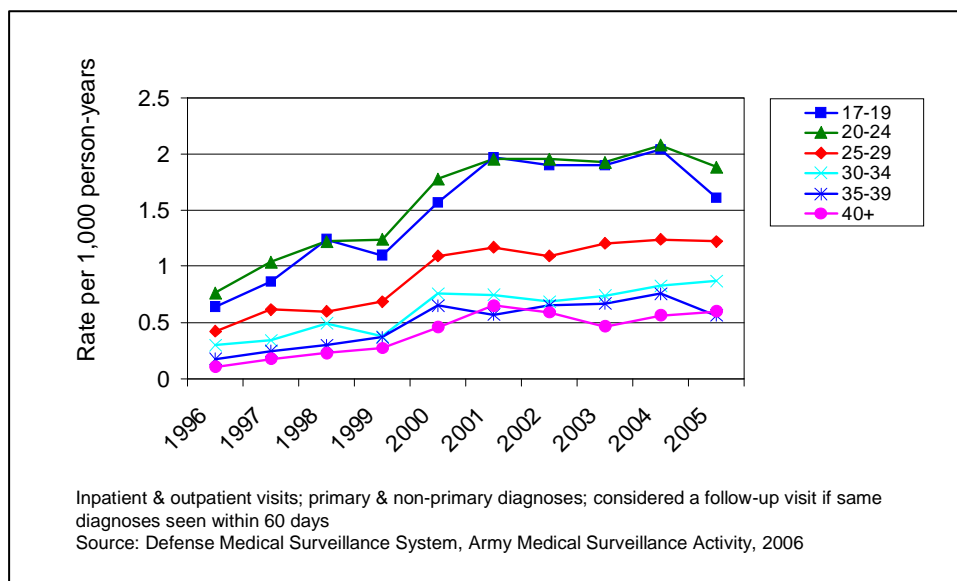


FIGURE 3-5-3. RATES OF ORAL-MAXILLOFACIAL FRACTURES BY AGE GROUP, ACTIVE DUTY MILITARY, 1996–2005

(5) Figure 3-5-4 shows the rates of oral-maxillofacial wounds by age group. Overall, the younger the age group, the higher the wound rate. The age groups 35–39 and 40+ had the lowest wound rates and had rates equal to one another. From 2000–2005, all age groups had a rise in wound rates, followed by a decline. Age groups 17–19 and 20–24 had peaks in 2002 (of ~22 wounds/1000 person-years and 20 wound/1000 person-years, respectively) followed first by small declines, then larger declines in 2005. Other age groups had slower, smaller increases in rates, followed by small peaks in 2004.

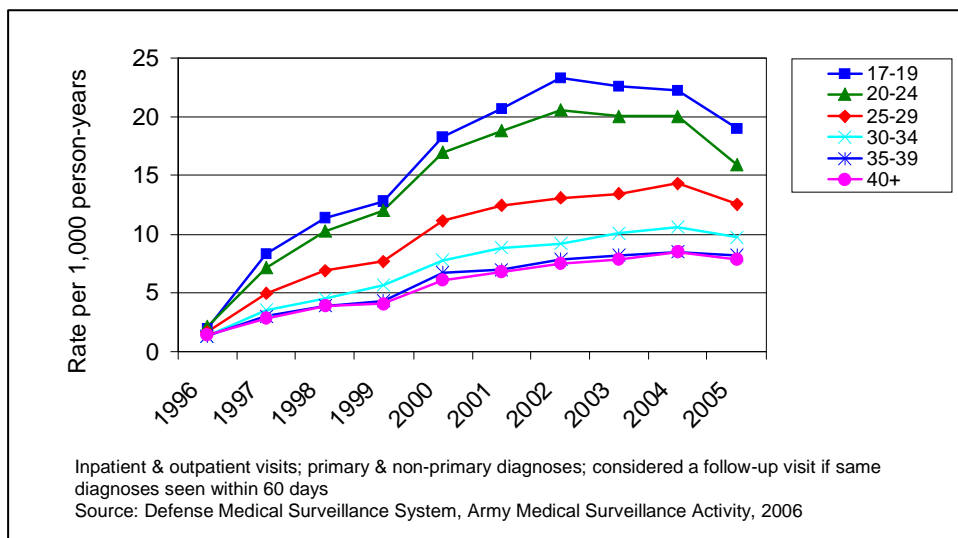


FIGURE 3-5-4. RATES OF ORAL-MAXILLOFACIAL WOUNDS BY AGE GROUP, ACTIVE DUTY MILITARY, 1996–2005

(6) The leading causes of hospitalization due to oral-maxillofacial injury in the Active Duty military in the CY 2005 are shown in Figure 3-5-5.

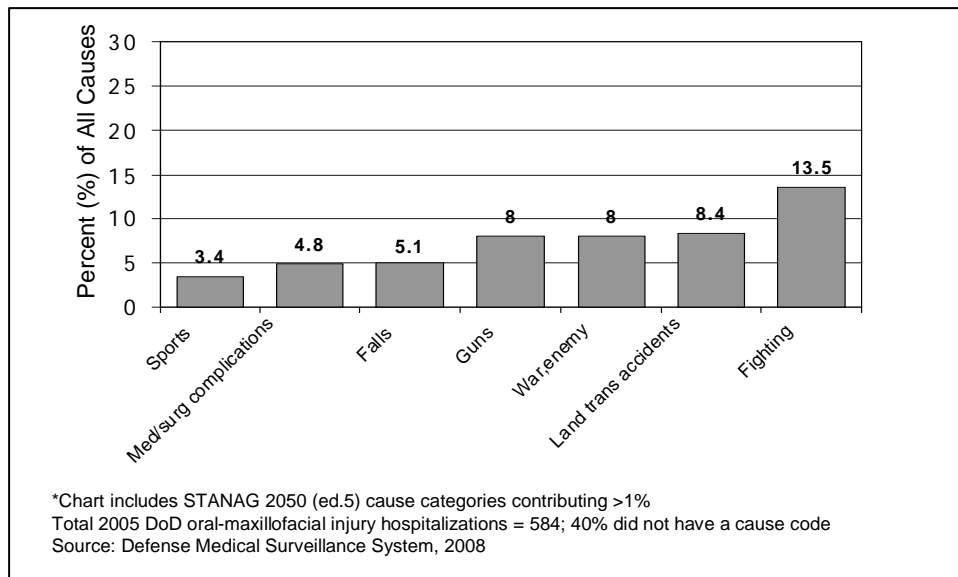


FIGURE 3-5-5. CAUSES OF ORAL-MAXILLOFACIAL INJURY, ACTIVE DUTY MILITARY, 2005

(7) Fighting was the leading cause of oral-maxillofacial injury requiring hospitalization. Fights (at 13.5 percent) were over 1.5 times as common as the next leading cause, land transportation accidents (8.4 percent). After land transportation accidents came enemy actions

during war (at 8.0 percent) and guns (8.0 percent), which were followed by falls (5.1 percent), medical and surgical complications (4.8 percent), and sports (3.4 percent).

D. DISCUSSION.

(1) As was expected, males had a higher oral-maxillofacial fracture rate than females. Katz showed that female Soldiers were significantly less likely to sustain a “dentofacial” injury than would be expected ($p < 0.01$).⁽⁶⁾ Mitchener found that females were also significantly less likely to be MEDEVACED for oral-facial illness or injury than would be expected ($p = 0.03$).⁽⁷⁾ It was surprising to find that males did not have a higher oral-maxillofacial wound rate than females. In fact, from 2000–2002, the opposite was true, the reasons for which are unknown.

(2) Regarding age groups, as expected, the younger the age group, the higher the rate for both oral-maxillofacial wounds and fractures. In addition, this analysis showed that age groups 17–19 and 20–24 had much higher rates for both wounds and fractures, as was seen in the Katz study, which suggested that 90 percent of such injuries occur by age 25.⁽⁶⁾

(3) In this study, fighting was found to be the leading cause of oral-maxillofacial injury for military personnel. A recent study found fighting to be the one of the major causes of Soldiers MEDEVACED out of Iraq and Afghanistan for nonbattle oral-facial injury, especially for Soldiers under age 30.⁽⁷⁾ Land transportation accidents (motor vehicle accidents) were the second leading cause of oral-maxillofacial injury in this study. Prior studies have revealed motor vehicle accidents as one of the top four causes of oral and craniofacial injuries.^(1, 6, 9, 10) and as the leading cause of nonbattle oral-facial injuries being MEDEVACED out of Iraq and Afghanistan.⁷

(4) In this study, unexpectedly, falls were found to be only the fifth leading cause of oral-maxillofacial injury for military personnel. Prior research has had falls as one of the top three causes of all oral and craniofacial injuries⁽¹¹⁾ and one of the top two causes for head and face injuries that enter emergency rooms.⁽¹⁾ It was also mildly surprising that sports were only the seventh leading cause of oral-maxillofacial injury hospitalizations, since past research has shown sports injuries as one of the top three causes of these types of injuries.^(1, 6, 9, 11, 12)

(5) The strengths of this study were the following: (1) the data collected were on all medical encounters of Active Duty military personnel; (2) all medical encounters were subject to standardized and routine recordkeeping; (3) the data collected came from a large patient population (approximately 1.3 million Active Duty military personnel have access to military health system care); and (4) the data captured care received both within the military health system and outside the military health system. A final strength of this study was having a study population (Active Duty military personnel) that had equal access to care.

(6) There were weaknesses and limitations to this study. These data are likely to be an underestimate of all oral-maxillofacial injuries for Active Duty Service members, as the

surveillance system does not capture treatment for minor injuries received at battalion-aid stations or medical care received in theaters of operation, such as Iraq and Afghanistan. It is also unknown: (1) how accurate the diagnoses of oral-facial injury were, (2) how many diagnoses were rendered by a dentist, oral-maxillofacial surgeon or other dental specialist, and (3) the level of dental training of the nondental providers making the diagnoses. A lack of basic dental knowledge could lead to misdiagnosis and (ICD-9-CM) misclassification. Also, there might have been a proper diagnosis, but the person entering the code(s) may not have entered the most specific or correct code.

(7) Looking toward prevention, most studies on the prevention of oral and craniofacial injuries have dealt with the use of helmets, facemasks, and mouth guards to protect athletes. Starting in 1962, a growing number of governing bodies of organized sports mandated the use of helmets, facemasks, and mouth guards (alone or in combination) in practice or in competition. Several professional health organizations (to include the American Medical Association[®] and the American Dental Association[®]) have recommended the use of helmets, facemasks, mouth guards, or a combination of these protective devices in a variety of contact sports at all levels of competition, both organized and unorganized.¹² In the military, the Army has required, since 2004, that mouth guards be issued to basic trainees and fitted at medical inprocessing. The mouthpieces are to be used during pugil stick training, confidence obstacle courses, unarmed combat, and rifle bayonet training.¹⁴ (American Medical Association[®] is a registered trademark of the American Medical Association; American Dental Association[®] is a registered trademark of the American Dental Association.)

(8) A systematic review of published studies in conducted in 2001 on behalf of the Task Force on Community Preventive Services found that available studies provided insufficient evidence to determine the effectiveness of population-based interventions that encourage use of oral-facial protection (such as, helmets, facemasks, and mouth guards) in contact sports in increasing oral-facial protection use or reducing injury or injury-related death.⁽¹⁵⁾ There were only four studies that qualified for the review, with fair quality of execution.^(12, 16) The study from those four with the greatest effect was the Benson study measuring hockey face shield effectiveness. This showed half face shields increased the relative risk (RR) of injury compared to full face shields (Head and Neck Injuries [Half Face/Full Face] RR=2.52; Facial Lacerations RR=2.31; Dental Injury only RR=9.90).⁽¹⁷⁾

(9) Since this report, additional intervention studies have demonstrated the effectiveness of certain types of craniofacial protectors. Marshall showed that use of faceguards in baseball reduced the risk of facial injury by 35 percent.⁽¹⁸⁾ Knapik found that the risk of oral-facial sports injury was 1.6-1.9 times higher when a mouth guard was not worn.⁽¹⁹⁾ dela Cruz found that Army basic trainees had about 1.8 times higher overall risk of oral-facial injury when mouth guards were not worn while engaged in four basic training activities (that is, pugil stick training, unarmed combat, rifle/bayonet training, and confidence/obstacle course) compared to when mouth guard use was mandated.⁽²⁰⁾

E. CONCLUSIONS AND RECOMMENDATIONS.

(1) The key findings of this study concerning oral-maxillofacial injury were the following: (1) Active Duty military males had a higher oral-maxillofacial fracture rate, 2000–2005, than females; (2) rates of oral-maxillofacial wounds were similar among males and females, 2000–2005, with females having a slightly higher rate than males in 2000–2002; (3) Active Duty military personnel under age 25 had the highest rates of both oral-maxillofacial fractures and wounds; and (4) fighting was the leading cause of oral-maxillofacial injury hospitalizations in 2005.

(2) The military would benefit from a system of surveillance that incorporates not only medical-care data but also dental-care data. Unfortunately, there are no known oral and craniofacial health surveillance systems. It is a goal of Healthy People 2010 (HP 2010), goal 21-16, to have an oral and craniofacial surveillance system in all states and the District of Columbia.⁽²¹⁾ At the present time, because of limited tracking data, this HP 2010 goal (21-16) could not be assessed for progress.⁽²²⁾

(3) In addition to surveillance needs, both the medical and dental care organizations need better coding of diagnoses, treatment, and causes. An avenue to get better and more accurate surveillance of oral-maxillofacial injury could involve greater education for medical personnel regarding diagnosis and treatment oral-maxillofacial trauma. A recent study evaluating the knowledge of military physicians and emergency medical technicians regarding dento-alveolar and maxillofacial injuries showed that only 22 percent received education regarding oral-maxillofacial trauma.⁽²³⁾ Improved knowledge will result in more accurate diagnoses and more accurate surveillance of these types of injuries.

(4) Overall, there is also a need for additional quality intervention studies on the strategies to prevent of oral and craniofacial injury. In addition to the 2001 review by the Task Force for Community Preventive Services, a 2005 review by U.S. and Canadian researchers concluded that the literature on sports-related cranio-maxillofacial injury prevention lacked the high quality scientific design and evidence on which mandatory interventions could be based.⁽²⁴⁾

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3-6. NONBATTLE INJURIES AIR-EVACUATED FROM OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM (U.S. ARMY), 2001–2006

A. INTRODUCTION.

(1) Nonbattle injuries (NBIs) have become a major cause of morbidity and mortality during combat operations. Whereas infectious disease was the leading cause of nonbattle hospitalization in World Wars I and II and the Korean War,⁽¹⁻³⁾ beginning with the Vietnam War, NBIs became the leading type of casualty.⁽⁴⁻⁶⁾ This shift in relative importance of NBIs since the Vietnam War has been described for Marines,^(1, 4, 5) Sailors,⁽¹⁾ and Soldiers.^(2, 7-10) During recent military deployments in Southwest Asia (Operations Desert Shield and Storm (ODS&S) in 1990–1991) and Bosnia (Operation Joint Endeavor (OJE), 1995–1996), NBIs (diagnosis codes 800–999, International Classification of Diseases, 9th Revision, Clinical Module (ICD-9-CM)) was the leading diagnosis category of hospitalizations, accounting for 25 percent and 20 percent, respectively.^(6, 7, 11) Hospitalizations for musculoskeletal and connective tissue conditions (diagnosis codes 716-739, ICD-9-CM) was the second leading diagnosis category of hospitalization in ODS&S (14 percent) and the fourth leading category in OJE (10 percent). Motor vehicle crashes (19 percent), falls (19 percent), and sports (18 percent) were the top three causes of NBI admissions in ODS&S.^(6, 11) Adding to the critical importance of NBIs in ODS&S, the number of nonbattle deaths from unintentional trauma (n=183) exceeded the number of battle-related deaths (n=147)⁽¹²⁾.

(2) Even though the impact of NBIs during military operations is well recognized, the epidemiology of these injuries is poorly understood. During past military operations, analyses to describe injury incidence, types, severity, causes, and treatment outcomes were conducted at the completion of the operations when copies of the medical records were centralized and available for review. Lessons learned from these retrospective analyses led to major advancements in medical evacuation, treatment, and rehabilitation that have greatly benefited injured Service members. This retrospective approach to injury surveillance, however, does not allow identification of injury problems early in the deployment when changes in practices and policy could possibly lower the injury risk for Soldiers during the deployment.

(3) Though the goal of military injury surveillance is to conduct high-quality, responsive, injury surveillance throughout the course of military operations, limitations in the current electronic medical record systems affect achievement of this goal. Limitations include the inability to identify all injury occurrences at any level of medical treatment in the theater (Level I–Level III) and the inadequate recording of precipitating injury causes. Efforts are underway at many levels within the Department of Defense (DOD) to improve existing medical systems, but in the meantime, these limitations reduce the effectiveness of injury surveillance efforts.

(4) In 2004, the Injury Prevention Program, U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) demonstrated that routinely collected air medical

evacuation data could be used to conduct ongoing injury surveillance during Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF).⁽¹³⁾ Two previous reports had also described the benefits of using the air-evacuation data for general medical surveillance during military operations.^(14, 15) The air-evacuation data system—U.S. Transportation Command (TRANSCOM) Regulating and Command and Control Evacuation System (TRAC2ES)—is used by the military to request and coordinate medical air evacuation of Service members with serious injuries and diseases. Important characteristics of these data that enable on-going deployment injury surveillance include: (1) complete capture of an important category of injuries—injuries serious enough to require air evacuation from the theater, (2) data completeness—all data elements must be entered before the patient can be air-evacuated, (3) standardized diagnosis codes from the ICD-9-CM, (4) documented injury cause and description of the injury incident in the patient history, (5) accessibility of air evacuation data—able to access for on-going routine surveillance, and (6) ability to link with data from other sources—accident reports, casualty reports, and medical (hospitalization) records.

(5) In May 2005 after recognizing the important contribution of using air evacuation data for deployment injury surveillance, the Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health tasked USACHPPM to conduct deployment injury surveillance for Soldiers deployed for OIF and OEF (see Figure 3-6-1). Results from these analyses have been used to monitor frequencies, rates, types, and causes of serious NBIs during these on-going military operations.



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY OF THE ARMY
INSTALLATIONS AND ENVIRONMENT
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MAY 02 2005

MEMORANDUM FOR COMMANDER, US ARMY MEDICAL COMMAND/THE SURGEON
GENERAL, 5109 LEESBURG PIKE, FALLS CHURCH, VA 22041
(ATTN: MS. SIL FINAMORE, DASG-ZXA)

SUBJECT: Request for USACHPPM Analyses of CENTCOM AOR Non-Battle Injuries

1. Non-battle injuries have been a major cause of morbidity and mortality during past combat operations. Preliminary analysis using medical evacuation data (TRAC2ES) in January 2004 by the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) showed that non-battle injuries accounted for 39% of air evacuations from the CENTCOM AOR for Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF). Many injuries within the three leading causes of non-battle injuries (falls, motor vehicle-related mishaps, and sports/physical training) may be preventable.

2. I request the assistance of the USACHPPM to provide on-going analyses of non-battle injuries that require air evacuation from the CENTCOM AOR and to identify potentially preventable causes of non-battle injuries. Specifically, it is requested that the USACHPPM identify and link medical, safety, and personnel data sources that document battle injuries, non-battle injuries, and diseases during deployments, such as OIF and OEF to:

a. Describe the distribution of diagnoses (ICD-9 codes) for Soldiers hospitalized in, or air evacuated from, the CENTCOM AOR.

b. Describe the relative impact and rates of non-battle injuries compared to battle-injuries and to other medical conditions and illnesses that required air evacuation, hospitalization, or other health care.

c. Identify causes of NBI that may be preventable.

d. Validate the diagnoses and causes of injuries from the medical evacuation data against other medical and safety data sources.

3. I thank you for your assistance with this. I am confident that this analysis will provide the Army with critical information for reducing Soldier injuries and enhancing readiness, combat effectiveness, well-being and morale. My point of contact is Mr. Jim Patton, 703-697-3123.


Raymond J. Fatz

Deputy Assistant Secretary of the Army
(Environment, Safety and Occupational Health)
OASA(I&E)

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FIGURE 3-6-1. DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR ENVIRONMENT, SAFETY AND OCCUPATIONAL HEALTH TASKER, 2005

(6) This section will describe the frequency, rate, injury types, and causes of NBIs that required medical air evacuation of U.S. Army Soldiers from U.S. Central Command (CENTCOM) since the beginning of OIF (March 2003) and OEF (October 2001) to December 2006.

B. METHODS.

(1) Soldiers who were air-evacuated for evaluation or treatment of an NBI while deployed in support of OIF or OEF were identified from routinely collected air-evacuation data (TRAC2ES) provided by the TRAC2ES System Program Office, Brooks Air Force Base. For this report, an NBI case was any Soldier (Regular Army, Army Reserve, or Army National Guard) deployed for OIF or OEF who was air-evacuated *from* CENTCOM to receive specialized treatment for an NBI between October 2001 and December 2006. If a Soldier had multiple air-evacuation movements as part of the continuum of medical care, it was considered a single NBI case. Only if the Soldier was air-evacuated from CENTCOM a second time (different timeframe) for a new, unrelated injury was it considered an additional case. The following data elements were abstracted from the air-evacuation data for Soldiers air-evacuated from CENTCOM: age, gender, rank, operation (OIF or OEF), date of air evacuation, origin and destination of each air evacuation movement, casualty type (battle injury (BI), disease/nonbattle injury (DNBI)), diagnosis code (ICD-9-CM), anatomical location of injury, and patient history.

(2) Data from two other systems were linked to the air-evacuation data to validate or acquire additional details about the Soldier's diagnosis, injury cause, and injury circumstances. These data systems were the Army Safety Management Information System (ASMIS) and Defense Casualty Information Processing System (DCIPS). These systems provided findings from accident investigations and casualty reports, respectively, for many of the NBI cases.

(3) Trained injury coders used a computerized data entry tool to review the combined data elements for all Soldiers air-evacuated from CENTCOM. Some of the most important data elements for this analysis were the medical diagnosis codes and text fields that described the case history and injury circumstances. After a thorough review of each case, important details about the case were recoded into new variables that could be used for this data analysis. Based on the ICD-9-CM diagnosis codes (TRAC2ES), casualty type codes (TRAC2ES, ASMIS, DCIPS), patient history (TRAC2ES, ASMIS, DCIPS), and incident circumstances (TRAC2ES, ASMIS, DCIPS), each air-evacuation case was classified as an NBI, BI, or disease. For each injury case (NBI and BI), cause of injury was determined from patient histories and were coded using a standardized coding scheme described in the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) No. 2050, 5th Edition and commonly referred to as the STANAG codes.⁽¹⁶⁾ Other important details about the injury events were also recoded for this analysis.

(4) Descriptive statistical methods were used to describe the: (1) frequency and rates of air evacuated NBIs, (2) demographic characteristics of Soldiers air-evacuated for NBIs, (3) distribution of medical diagnosis groups for all air-evacuation cases, (4) distribution of NBI types and anatomical locations, and (5) distribution of NBI causes. The Chi-square test of proportions was used to compare distributions for OIF and OEF. To calculate estimated NBI rates (injuries/1000 deployed person-years), the estimated deployed person-time for each year (2001 to 2006) of each operation was obtained from the Armed Forces Health Surveillance Center. All results were reported separately for OIF and OEF.

C. RESULTS.

(1) For the period October 2001 to December 2006, a total of 11,045 Soldiers were air-evacuated from CENTCOM (OIF: n=9,530; OEF: n=1,515) for an NBI. These NBIs accounted for 34.6 percent and 36.4 percent of air evacuations from OIF and OEF, respectively.

(2) Demographic characteristics including age, gender, and military rank of Soldiers air-evacuated from OIF and OEF for an NBI are described in Table 3-6-1. The OIF Soldiers were similar in age ($p=0.31$) and gender ($p=0.22$) to those air-evacuated from OEF. Overall, more than half of OIF and OEF Soldiers were under the age of 30 (OIF: 51.6 percent; OEF: 53.0 percent) and more than 80 percent were under the age of 40 (OIF: 82.1 percent; OEF: 82.8 percent). Female Soldiers accounted for only 8.6 percent and 7.6 percent of NBIs for OIF and OEF, respectively. More Soldiers in OIF were E-7 or below (89.0 percent; $p<0.001$) compared to OEF (84.5 percent), while more OEF Soldiers were senior noncommissioned officers (E-8 and E-9) ($p=0.01$), senior officers (O-4 - O-7) ($p=0.01$) and warrant officers ($p=0.01$).

TABLE 3-6-1. AGE, GENDER, AND MILITARY RANK OF SOLDIERS AIR-EVACUATED FOR NONBATTLE INJURIES, OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM, 2001–2006

Characteristic and Category	OIF ^a (n=9,530)		OEF ^b (n=1,515)	
	Frequency (n)	Percent (%)	Frequency (n)	Percent (%)
Age Group				
17-19	256	2.7	51	3.4
20-29	4,661	48.9	751	49.6
30-39	2,904	30.5	452	29.8
40-49	1,381	14.5	204	13.5
50-59	310	3.3	51	3.4
60+	2	0.0	0	0.0
Unknown	16	0.2	6	0.4
Gender				
Male	8,712	91.4	1,399	92.3
Female	814	8.6	115	7.6
Unknown	4	0.0	1	0.1

TABLE 3-6-1. AGE, GENDER, AND MILITARY RANK OF SOLDIERS AIR-EVACUATED FOR NONBATTLE INJURIES, OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM, 2001–2006 (CONTINUED)

Characteristic and Category	OIF ^a (n=9,530)		OEF ^b (n=1,515)	
	Frequency (n)	Percent (%)	Frequency (n)	Percent (%)
Military Rank				
Enlisted				
Junior enlisted, E1-E4	4,486	47.1	666	44.0
NCO, E5-E7	3,997	41.9	613	40.5
NCO, E8-E9	184	1.9	49	3.2
Officer				
Company grade, O1-O3	378	4.0	63	4.2
Field grade, O4-O7	202	2.1	48	3.2
Warrant officer, W1-W4	162	1.7	44	2.9
Unknown	121	1.3	32	2.1

Notes;

^a OIF - March 2003–December 2006.^b OEF - October 2001–December 2006.

(3) While the overall NBI rates (NBIs/1000 deployed person-years) for OIF (2003-2006) and OEF (2001-2006) differed ($p < 0.001$) (Table 3-6-2), the combined yearly rates for years 2003 to 2006 when both operations were ongoing were the same (OIF: 18.4; OEF: 18.4; $p = 0.93$). Different patterns were noted, however, when comparing yearly rates between and within operations. In 2003, the OIF rate was at its highest level and was two times higher than the OEF rate. The OIF rate then decreased 29 percent in 2004 and continued to decrease in each subsequent year (2005 and 2006). The OEF rate was lowest during the first 2¼ years of the operation (October 2001–2003) but increased by 80 percent in 2004, only to fall in 2005 and then rise again in 2006. For years 2004–2006, the yearly OIF rates were lower than the OEF rates.

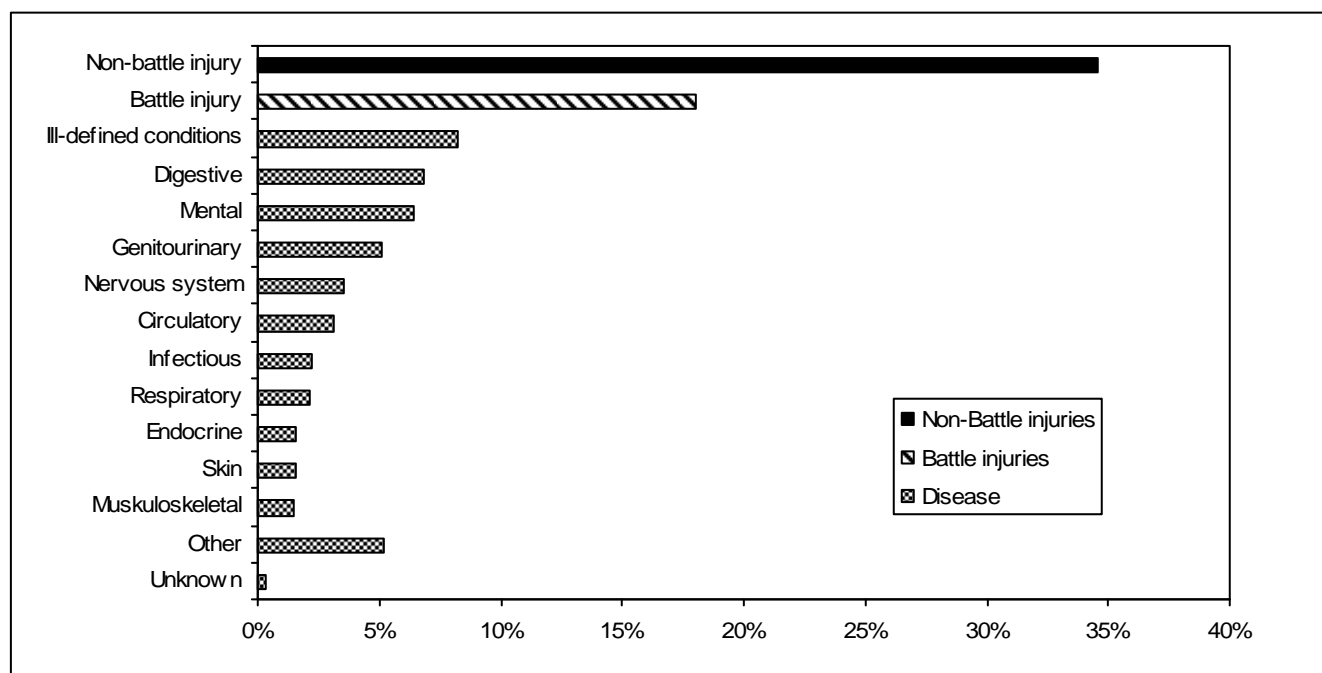
TABLE 3-6-2. INJURY RATES FOR AIR-EVACUATED NONBATTLE INJURIES, U.S. ARMY, OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM, 2001–2006

Year	OIF ^a (n=9,530)		OEF (n=1,515)	
	Frequency (n)	Rate ^b	Frequency (n)	Rate ^b
CY 2001+2002 ^c	NA	NA	215	9.31
CY 2003	3,333	27.16	273	13.41
CY 2004	2,395	19.25	356	24.15
CY 2005	2,236	15.47	300	17.93
CY 2006	1,566	12.40	371	19.89
Total	9,530	18.40	1,515	16.19

Notes:

^a OIF began on 19 March 2003.^b Rate is the number of NBIs per 1000 deployed person-years.^c Frequency for OEF includes October 2001 to December 2002.

(4) A total of 27,563 Soldiers were air-evacuated from OIF from March 2003 to December 2006, including NBIs, BIs, and diseases. Figure 3-6-2 shows the distribution of these evacuations by injury type (NBI or BI) or diagnosis group for diseases. Nonbattle injury was the largest single diagnosis category (34.6 percent) even though all disease categories combined accounted for 47.4 percent. Battle injury, the second leading diagnosis category, accounted for 18.0 percent of evacuations. Ill-defined signs and symptoms (8.2 percent) and digestive disorders (6.8 percent) were the 3rd and 4th leading categories.



NOTES:

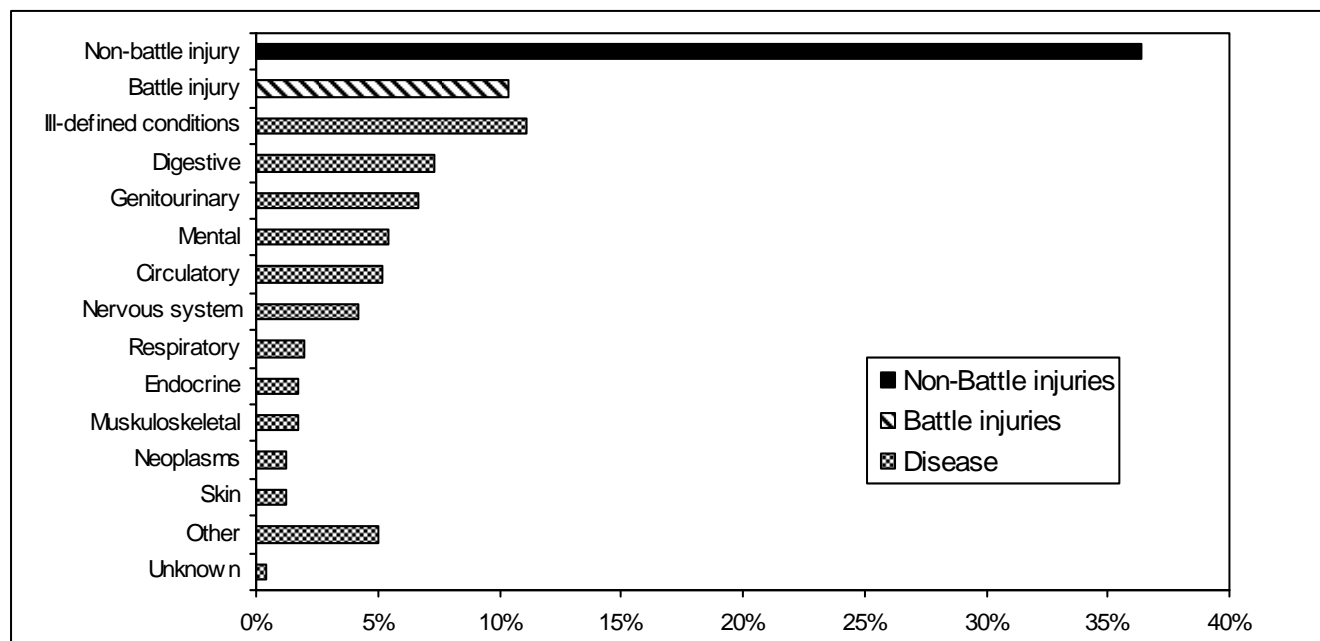
^a Total evacuations: n=27,563.

^b Percents represent the percent of all evacuations within each group.

^c OIF: March 2003–December 2006.

FIGURE 3-6-2. DISTRIBUTION OF OPERATION IRAQI FREEDOM AIR-EVACUATED NONBATTLE INJURIES BY INJURY TYPE AND PRIMARY DIAGNOSIS GROUP, U.S. ARMY, 2003–2006^{a-c}

(5) From October 2001 to December 2006, a total of 4,165 Soldiers were air-evacuated from OEF, including NBIs, BIs, and diseases. Figure 3-6-3 shows the distribution of these evacuations by their injury type (NBI or BI) or diagnosis group for diseases. Similar to the findings for OIF, NBI was the largest single diagnosis category (36.4 percent), even though all disease categories combined accounted 53.2 percent of air evacuations. The proportion of NBI evacuations was 3.3 times higher than the next largest category, ill-defined signs and symptoms (11.1 percent), which included a variety of symptoms not generally associated with a specific disease or medical condition. The third and fourth leading categories were BI (10.4 percent) and digestive disorders (7.3 percent). In OEF, BIs accounted for a smaller proportion of the air evacuations than in OIF.



Notes:

a Total evacuations: n=4,165

b Percents represent the percent of all evacuations within each group

c OEF: October 2001–2006

FIGURE 3-6-3. DISTRIBUTION OF OPERATION ENDURING FREEDOM AIR-EVACUATED NONBATTLE INJURIES BY INJURY TYPE AND PRIMARY DIAGNOSIS GROUP, U.S. ARMY, 2001–2006^{a-c}

(6) The NBIs were classified by general diagnosis and anatomical location. For OIF and OEF, the distributions and rank order for diagnosis ($p=0.32$) and anatomical location ($p=0.51$) were similar. The top five diagnosis categories were: (1) fracture (OIF: 18.9 percent; OEF: 18.8 percent), (2) inflammation and pain (overuse) (OIF: 18.2 percent; OEF: 17.6 percent), (3) dislocation (OIF: 11.7 percent; OEF: 12.9 percent), (4) sprain/strain (OIF: 10.7 percent; OEF: 11.6 percent), and (5) other joint internal derangement (OIF: 6.1 percent; OEF: 6.8 percent). The top five anatomical location categories were: (1) back (OIF: 18.0 percent; OEF: 16.6 percent), (2) knee (OIF: 15.4 percent; OEF: 15.9 percent), (3) wrist/hand (OIF: 12.9 percent; OEF: 12.3 percent), (4) ankle/foot (OIF: 11.3 percent; OEF: 10.7 percent), and (5) shoulder (OIF: 9.3 percent; OEF: 10.2 percent).

(7) Nonbattle injuries were further categorized by their primary (1st listed) diagnosis into two major sub-groups—acute traumatic injuries (OIF: n=5,035; OEF: n=817) and injury-related musculoskeletal conditions (OIF: n=2,667; OEF: n=428)—that together accounted for 80.8 percent of NBIs in OIF and 82.2 percent of NBIs in OEF. The remainder of the NBIs did not allow classification into meaningful subgroups. The larger subgroup, acute traumatic injuries, included NBIs with a diagnosis classified in Chapter 17, ICD-9-CM (Injury and Poisoning).

This subgroup accounted for 52.8 percent of NBIs in OIF and 53.9 percent of NBIs in OEF. The other subgroup, injury-related musculoskeletal conditions, included NBIs with a diagnosis classified in Chapter 13, ICD-9-CM (Diseases of the Musculoskeletal System and Connective Tissue). This subgroup comprised 28.0 percent of OIF NBIs and 28.3 percent of OEF NBIs.

(8) Tables 3-6-3 and 3-6-4 are Barell Injury Matrices for OIF (n=5,035) and OEF (n=817), respectively. These matrices provide a standardized format to describe the acute traumatic injuries (the first subgroup of NBIs) by their injury type (horizontally, across the top) and body region (vertically, on the left side). The three largest injury type categories for OIF (Table 3-6-3) and OEF (Table 3-6-4) were fractures, dislocations, and sprains/strains. Combined, these 3 categories accounted for 71.3 percent of traumatic injuries in OIF and 73.2 percent in OEF. All other injury type categories were smaller by comparison. Fractures accounted for one-third of the traumatic injuries air-evacuated from OIF and OEF. Injuries involving the lower extremity and upper extremity accounted for 39.5 percent and 34.4 percent, respectively, of traumatic injuries in OIF and 41.2 percent and 36.1 percent, respectively, of these injuries in OEF. For both operations, the knee was the largest subcategory within the lower extremity and overall. The wrist/hand/fingers were the largest subcategory within the upper extremity and the second largest category overall for both operations.

(9) Tables 3-6-5 and 3-6-6 are similarly formatted matrices that categorize the injury-related musculoskeletal conditions (the second subgroup of NBIs) for OIF (n=2,667) and OEF (n=428), respectively. For both operations, the three leading injury type categories, in descending order, were: (1) inflammation and pain (overuse), (2) joint derangement, and (3) joint derangement with neurological involvement. These three categories accounted for 86.8 percent and 86.2 percent of injury-related musculoskeletal conditions in OIF and OEF, respectively. Injuries involving the vertebral column and lower extremity accounted for 55.4 percent and 23.0 percent, respectively, of the injury-related musculoskeletal conditions in OIF and 49.8 percent and 27.6 percent, respectively, in OEF.

(10) The distribution and ranking of NBI causes were similar for OIF and OEF (Table 3-6-7). Note that the category percentages were based on evacuations for which cause of injury was specified. The four leading categories for both operations, in descending order, were: (1) sports and physical training, (2) falls/jumps, (3) motor vehicle-related accidents, and (4) crushing or blunt trauma. Comparing the two operations, the largest difference for any injury cause category was 4.7 percent (motor vehicle-related accidents).

D. DISCUSSION.

(1) From October 2001 to December 2006, 9,530 OIF Soldiers and 1,515 OEF Soldiers were medically evacuated by air from CENTCOM for evaluation or treatment of an NBI. Of all air-evacuated Soldiers, 35 percent of OIF Soldiers and 36 percent of OEF Soldiers had NBIs, making NBI the largest single diagnosis category. Characteristics of Soldiers with NBIs were

similar for both operations. They were predominately male (91-92 percent), younger than 40 years (82-83 percent), and enlisted rank E-1–E-7 (85-89 percent). Leading injury types and anatomic locations of NBIs were similar for both operations. Leading injury types were fracture, inflammation and pain (overuse), dislocation, and sprain/strain. The back was most commonly involved (17-18 percent), followed by the knee, wrist/hand, ankle/foot, and shoulder. The leading injury causes were also the same for both operations—sports/physical training, falls/jumps, and motor vehicle-related accidents.

TABLE 3-6-3. OPERATION IRAQI FREEDOM BARELL INJURY MATRIX (ICD-9-CM CODES 800-999) FOR AIR-EVACUATED NONBATTLE INJURIES, U.S. ARMY, 2003–2006

			Fracture	Dislocation	Sprains/ Strains	Internal	Open Wound	Amputations	Blood Vessel	Contusion/Su- perficial	Crush	Burns	Nerves	Unspeci- fied	System- wide & late effects	Total	Total Percent	
Head and Neck	Traumatic Brain Injury (TBI)	Type 1 TBI	1			17							0			18	0.4	
		Type 2 TBI	10			30										40	0.8	
		Type 3 TBI	1													1	0.0	
	Other Head, Face, Neck	Other head					9						0	1	48		58	1.2
		Face	90	0	0		13						28				131	2.6
		Eye					18			8		3	0				29	0.6
		Neck	0		0		2				0	0	10				12	0.2
		Head, Face, Neck Unspec.							2	0	2	8	0	15			27	0.5
Spine and Back	Spinal Cord (SCI)	Cervical SCI	4			8										12	0.2	
		Thoracic/Dorsal SCI	2			0										2	0.0	
		Lumbar SCI	2			15										17	0.3	
		Sacrum Coccyx SCI	0			4										4	0.1	
		Spine, Back Unspec. SCI	4			10										14	0.3	
	Vertebral Column (VCI)	Cervical VCI	21	2	32												55	1.1
		Thoracic/Dorsal VCI	4	1	1												6	0.1
		Lumbar VCI	34	0	26												60	1.2
		Sacrum Coccyx VCI	3	0	1												4	0.1
		Spine, Back Unspec. VCI	8	0													8	0.2
Torso	Torso	Chest (thorax)	21	1	7	17	6		1	3	0	1	0			57	1.1	
		Abdomen				11	10		1	1		0	6			29	0.6	
		Pelvis, Urogenital	52	2	8	2	4		0	0	0	1	1			70	1.4	
		Trunk	2				0			2	0	2	2	7		15	0.3	
Extremities	Upper	Back, Buttock			28		0			3	4	0				35	0.7	
		Shoulder, Upper Arm	91	218	225		12	0		17	1	3			18		585	11.6
		Forearm, Elbow	198	28	18		8	0		3	4	5					264	5.2
		Wrist, Hand, Fingers	279	62	43		146	53		13	36	28		110			770	15.3
	Lower	Other & Unspec.	4				3	1	2	2	3	8		87	7		117	2.3
		Hip	20	12	13					5	0						50	1.0
		Upper leg, Thigh	47					0		2	0	4					53	1.1
		Knee	32	719	64					18	2	1					836	16.6
		Lower leg, Ankle	384	20	89			1		2	3	7					506	10.0
		Foot, toes	187	16	13		35	3		17	19	4					294	5.8
Unclass. by Site	Other, Unspecified	Other & Unspec.	4		111		39	0	8	6	3	2		80		253	5.0	
		Other/Multiple Unspec. Site	1						1			1	9			12	0.2	
	System-wide & late effects		272	30	20	1	17		1	7	2	15	18	13			396	7.9
	System-wide & late effects														195	195	3.9	
	Total		1778	1111	699	115	322	58	16	109	79	121	134	298	195	5035		
	Total Percent		35.3	22.1	13.9	2.3	6.4	1.2	0.3	2.2	1.6	2.4	2.7	5.9	3.9		100%	

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TABLE 3-6-4. OPERATION ENDURING FREEDOM BARELL INJURY MATRIX (ICD-9-CM CODES 800–999) FOR AIR-EVACUATED NONBATTLE INJURIES, U.S. ARMY, 2001–2006

			Fracture	Dislocation	Sprains/ Strains	Internal	Open Wound	Amputations	Blood Vessel	Contu- sion/Su- perficial	Crush	Burns	Nerves	Unspec- ified	System- wide & late effects	Total	Total Percent	
Head and Neck	Traumatic Brain Injury (TBI)	Type 1 TBI	2			2							0			4	0.5	
		Type 2 TBI	4			1										5	0.6	
		Type 3 TBI	0													0	0.0	
	Other Head, Face, Neck	Other head					4						0	0	12		16	2.0
		Face	13	0	0		5						1				19	2.3
		Eye					8			2			0	0			10	1.2
		Neck	0		0		0					1	0	2			3	0.4
		Head, Face, Neck Unspec.							2	1	0	2	0	0	3		8	1.0
Spine and Back	Spinal Cord (SCI)	Cervical SCI	2			2											4	0.5
		Thoracic/Dorsal SCI	1			0											1	0.1
		Lumbar SCI	1			1											2	0.2
		Sacrum Coccyx SCI	1			0											1	0.1
		Spine, Back Unspec. SCI	0			4											4	0.5
	Vertebral Column (VCI)	Cervical VCI	4	0	2												6	0.7
		Thoracic/Dorsal VCI	1	0	0												1	0.1
		Lumbar VCI	5	0	5												10	1.2
		Sacrum Coccyx VCI	0	0	0												0	0.0
		Spine, Back Unspec. VCI	1	0													1	0.1
Torso	Torso	Chest (thorax)	1	0	0	1	1		0	0	0	0	0				3	0.4
		Abdomen				3	1		0	0		0	0				4	0.5
		Pelvis, Urogenital	7	0	0	0	0		0	0	0	0	0				7	0.9
		Trunk	0				0			1	1	0	0	2			4	0.5
		Back, Buttock			1		0			0	1	0					2	0.2
Extremities	Upper	Shoulder, Upper Arm	12	32	47		2	1		1	0	0		2			97	11.9
		Forearm, Elbow	26	4	2		1	1		0	1	1					36	4.4
		Wrist, Hand, Fingers	71	10	12		10	9		2	7	4		11			136	16.6
		Other & Unspec.	0				0	1	1	0	0	1	22	1			26	3.2
	Lower	Hip	5	3	5					0	0	0					13	1.6
		Upper leg, Thigh	7					0		1	1	0					9	1.1
		Knee	1	135	8					0	0	0					144	17.6
		Lower leg, Ankle	72	3	21			1		0	0	1					98	12.0
		Foot, toes	23	1	3		4	1		3	5	0					40	4.9
Unclass. by Site	Other, Unspecified	Other & Unspec.	0		10		3	1	1	0	1		16			33	4.0	
		Other/Multiple	0						0			0	4			4	0.5	
		Unspec. Site	21	5	8	0	2		0	1	0	3	1	3		44	5.4	
	System-wide & late effects														22	22	2.7	
	Total	281	193	124	14	41	15	4	13	17	14	29	50	22	817			
	Total Percent	34.4	23.6	15.2	1.7	5.0	1.8	0.5	1.6	2.1	1.7	3.5	6.1	2.7			100%	

TABLE 3-6-5. OPERATION IRAQI FREEDOM INJURY-RELATED MUSCULOSKELETAL CONDITION MATRIX (ICD-9-CM CODES 716-739) FOR AIR-EVACUATED NONBATTLE INJURIES, U.S. ARMY, 2003–2006

Injury Location			Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurological	Stress Fracture	Sprains/Strains/ Rupture	Dislocation	Total	Percent Total
Spine and Back	Vertebral Column	Cervical	66	84	37				187	7.0
		Thoracic/Dorsal		6	34				40	1.5
		Lumbar	331	161	37				529	19.8
		Sacrum Coccyx	2						2	0.1
		Spine, Back Unspecified	448	76	194	1			719	27.0
Extremities	Upper	Shoulder	211	25			71	7	314	11.8
		Upper Arm, Elbow	19	3		0		0	22	0.8
		Forearm, Wrist	7	5		3		0	15	0.6
		Hand	13	4			18	0	35	1.3
	Lower	Pelvis, Hip, Thigh	20	0		2	6	0	28	1.0
		Lower leg, Knee	72	190		7	191	0	460	17.2
		Ankle, Foot	105	19			4	0	128	4.8
Unclassified by Site	Other, Unspecified	Other specified/Multiple	19	3		1	1	0	24	0.9
		Unspecified Site	54	2	65	13	30	0	164	6.1
Total			1367	578	367	27	321	7	2667	
Percent Total			51.3	21.7	13.8	1.0	12.0	0.3		100%

TABLE 3-6-6. OPERATION ENDURING FREEDOM INJURY-RELATED MUSCULOSKELETAL CONDITION MATRIX (ICD-9-CM CODES 716-739) FOR AIR-EVACUATED NONBATTLE INJURIES, U.S. ARMY, 2001–2006

Injury Location			Inflammation and Pain (Overuse)	Joint Derangement	Joint Derangement with Neurological	Stress Fracture	Sprains/Strains/Rupture	Dislocation	Total	Percent Total
Spine and Back	Vertebral Column	Cervical	7	16	14				37	8.6
		Thoracic/Dorsal		1	7				8	1.9
		Lumbar	68	24	6				98	22.9
		Sacrum Coccyx	0						0	0.0
		Spine, Back Unspec	37	23	9	1			70	16.4
Extremities	Upper	Shoulder	33	9			11	3	56	13.1
		Upper Arm, Elbow	4	0		0		0	4	0.9
		Forearm, Wrist	1	0		1		0	2	0.5
		Hand	0	1			3	0	4	0.9
	Lower	Pelvis, Hip, Thigh	7	0		0	1	0	8	1.9
		Lower leg, Knee	30	26		1	30	0	87	20.3
		Ankle, Foot	20	2			1	0	23	5.4
Unclassified by Site	Other, Unspecified	Other specified/Multiple	1	1		0	2	0	4	0.9
		Unspec. Site	6	0	16	1	4	0	27	6.3
Total			214	103	52	4	52	3	428	
Percent Total			50.0	24.1	12.1	0.9	12.1	0.7		100%

TABLE 3-6-7. DISTRIBUTION AND RANKING OF CAUSES OF INJURY FOR AIR-EVACUATED NONBATTLE INJURIES, U.S. ARMY, OPERATIONS IRAQI FREEDOM AND ENDURING FREEDOM, 2001–2006

Cause of Injury ^c	OIF ^a			OEF ^b		
	Frequency (n)	Percent (%)	Rank	Frequency (n)	Percent (%)	Rank
Sports and physical training	1,163	18.5	1	195	20.5	1
Falls/Jumps	1,114	17.7	2	170	17.9	2
Motor vehicle-related accidents	1,020	16.2	3	109	11.5	3
Crushing or blunt trauma	533	8.5	4	85	8.9	4
Lifting, pushing, pulling	517	8.2	5	66	6.9	6
Twisting, turning, slipping	425	6.8	6	67	7.1	5
Shoes, clothing, body armor	263	4.2	7	29	3.1	8
Cutting and piercing	194	3.1	8	17	1.8	10
Handling weapons and explosives	191	3.0	9	31	3.3	7
Environmental	171	2.7	10	24	2.5	9
Other specified	700	11.1		157	16.5	
Total	6,291	100.0		950	100.0	

Notes:

^a Includes injuries for which the NBI cause was specified (66.1 percent), OIF: March 2003–December 2006.

^b Includes injuries for which the NBI cause was specified (62.7 percent), OEF: October 2001–December 2006.

^c Causes of injury are listed in descending order based on their distribution for OIF.

(2) Comparable (complete) air-evacuation data from previous military operations are not available. Direct comparison of air-evacuated NBI rates, types, and causes is, therefore, not possible. However, two reports from medical treatment facilities that treated air evacuated Soldiers during ODS&S were reviewed. Both described similarly high proportions of NBIs among air evacuees.^(17, 18) At the 13th Evacuation Hospital in Saudi Arabia, 721 evacuees were treated as outpatients.⁽¹⁷⁾ Of these, 48 percent had NBIs, 20 percent had musculoskeletal conditions, which were probably NBIs, 8 percent had BIs, and 24 percent had a disease/illness. Of the 435 evacuees who were hospitalized at the 13th Evacuation Hospital, 39 percent had NBIs, 14 percent had BIs, and 47 percent had a disease/illness. Travis described 180 patients air evacuated from ODS&S and treated at Madigan Army Medical Center.⁽¹⁸⁾ Of these, 46 percent had orthopedic NBIs, 6 percent had orthopedic BIs, and 48 percent were admitted by other specialties and included some (number not reported) NBIs and BIs.

(3) The overall NBI rate for OIF (2003-2006) was 14 percent higher than the OEF rate (2001-2006), but when the rates were compared for the same timeframe (2003-2006), the rates were similar. When yearly rates were compared between and within operations, important differences were seen. Except for 2003, the yearly rates for OEF were higher than for OIF. The OIF rates gradually decreased over time from their high in 2003. This decrease in OIF air-evacuated NBI rates was most likely related to the gradual maturing of the OIF theater with access to higher levels of in-theater medical care. The OEF rate was lowest during the first 2¼ years of the operation (2001-2003) but increased by 80 percent in 2004, only to fall in 2005 and then rise again in 2006. These NBI rate differences may be related to different injury risks and hazards that are dependent on timeframe and operation. For example, certain factors inherent with deployment to OEF may have increased these Soldiers' NBI risk while other factors associated with deployment to OIF appear to have lowered the injury risk over time. Some of the factors affecting these differences may have been: (1) accessibility and level of medical care available in theater, (2) terrain (rural, mountainous vs. urban), (3) weather conditions, (4) road conditions, (5) military vehicle types, (6) frequency of dismounted vs. mounted patrols, (7) permanence and quality of facilities and installations, and (8) maturity of logistical support. Differences in these factors may individually or, most likely, in combination influence the NBI risk for deployed Soldiers and may be responsible for the differences noted in OIF and OEF NBI rates. However, these potential risk factors and their association with NBIs during military operations have not been evaluated during past or present deployments.

(4) Combat intensity may be another factor that influenced the NBI rates in OIF and OEF. Three reports have evaluated the association between combat intensity and NBI injury rates during previous operations.⁽¹⁹⁻²¹⁾ Two of these found that higher combat intensity was associated with higher NBI rates.^(19, 21) Blood compared DNBI rates among Marines involved in different phases of the assault on Okinawa (World War II) and among Marines assigned to rifle, weapons, and headquarter units during the Korean War.⁽¹⁹⁾ Higher combat intensity was associated with a higher DNBI incidence. However, when the same author evaluated the

relationship between combat intensity and DNBI rates during the Hue offensive in Vietnam, battle intensity did not affect DNBI incidence.⁽²⁰⁾ Wojcik compared the disease rates and NBI rates during the three phases of ODS&S—the build-up, ground combat, and post-combat phases.⁽²¹⁾ There were no differences in the disease rates for these three periods, but the NBI rate for the combat phase was 2.7 times higher than the rate for the build-up phase and 2.6 times higher than the rate for the post-combat phase. The degree to which the different levels of combat intensity in OIF compared to OEF, or during different timeframes for each operation, may have influenced NBI rates is unknown. Data for this type of analysis is not currently available for OIF or OEF.

(5) Air-evacuated NBIs, no matter the severity, negatively affected combat readiness and effectiveness for the Soldiers and their units. These were the most serious, chronic, debilitating, or activity-limiting of nonfatal NBIs. Air evacuation was required for numerous reasons, including: (1) specialized surgical or inpatient care, (2) prolonged recuperation or rehabilitation, (3) specialized diagnostic procedure, (4) examination or treatment by a medical specialty not available in theater, and (5) fitness-for-duty evaluation. Even the least severe of these injuries would have required repeated absences from the unit to attend medical appointments in theater and/or while evacuated from the theater, as well as temporary duty restrictions limiting job performance. The more severe injuries would have resulted in longer and more limiting duty restrictions, prolonged absence from the unit, and greater potential for long-term disability. As a result, all of these air-evacuated nonbattle injuries, no matter the severity, negatively impact duty performance and unit readiness in the combat zone.

(6) Leading injury types that were air evacuated, in decreasing rank order, were fractures, inflammation and pain (overuse), dislocations, and sprain/strain. Since comparable air-evacuation data from previous operations are not available, hospitalization data provides the only possible comparison. For ODS&S, Writer reported that fractures (25 percent) was the leading type of NBI requiring hospitalization and was also the leading contributor to hospitalization days.⁽⁶⁾ The next leading injury categories were (in decreasing rank order) sprains/strains, other injury, and dislocations. Writer's findings are consistent with the findings of this current report.

(7) A unique strength of this current analysis was the ability to identify and classify causes of injury for NBIs that were medically evacuated from OIF and OEF. Linking air-evacuation data with accident reports and casualty data provided a unique opportunity to further identify injury causes. The leading causes of injury for OIF and OEF were identical. The top three causes were sports/physical training (19-21 percent), falls/jumps (18 percent), and motor vehicle-related accidents (11-16 percent). Again, since there are no comparable reports of injury causes for air-evacuated NBIs for previous operations, comparison will be made to hospitalization data. In ODS&S, the leading NBI causes of hospitalization were motor vehicle crashes (19 percent), falls (19 percent), and sports/athletics (18 percent)⁽⁶⁾. These three leading

causes of NBI for hospitalization were the same as the leading three causes for air evacuation from OIF and OEF.

(8) At first look, it may be surprising that sports and physical training were the leading causes of nonbattle injury in OIF and OEF considering the nature and combat intensity of these operations. Participation in sports activities, however, is an important and appropriate leisure time activity during deployments, as in garrison. Soldiers are required to participate in physical training. Participation in sports is encouraged and allows Soldiers to enhance their physical fitness and encourages a healthy lifestyle, including weight and stress management. Sports also improves esprit de corps and morale. But injury risk is also increased with participation in these activities.⁽²²⁻²⁸⁾ Garrison and peacetime injury rates are also high. Between 1989 and 1994, the sports-related injury hospitalization rate for Soldiers was 36 injuries/10,000 person-years.⁽²⁷⁾ Among nondeployed Soldiers (2004–2005), sports were the 4th leading cause of injury hospitalizations in the Army, comprising 10 percent of injury hospitalizations.⁽²⁹⁾

(9) Four other reports have recognized sports as an important cause of injury during deployments. A recent report from OEF described a suspected increase in basketball-related injuries among Soldiers after a concrete basketball court was opened at a forward operating base in Afghanistan.⁽³⁰⁾ In ODS&S, sports and athletics accounted for 18 percent of NBI hospitalizations.⁽⁶⁾ McKee reported that sports injuries accounted for 21 percent of primary care visits for orthopedic NBIs among U.S. Forces participating in Operation Joint Guard during 2007.⁽⁸⁾ Similarly, among British troops deployed in Bosnia for Operation Resolute in 1995–1996 (same timeframe as Operation Joint Endeavor for U.S. Forces), sports accounted for 11 percent of all NBIs.⁽³¹⁾ It was also noted that the incidence of sports injuries increased steadily as this operation progressed.

(10) This report provides the first analysis of air-evacuated NBIs for an on-going Army deployment. Routinely collected air-evacuation data, supplemented with data from accident investigations and casualty reports, allowed capture of all air-evacuated injury cases and provided sufficient detail to classify injuries by their type, anatomical location, and cause. This has allowed ongoing injury surveillance and analysis throughout the course of the current on-going operations (OIF and OEF). The NBI rates, types, and causes have been recognized early during these deployments and should allow commanders and Army leaders to focus attention on developing and evaluating prevention countermeasures and policies that may lower injury risk for currently deployed Soldiers.

E. CONCLUSION. Routinely collected air-evacuation data provided the basis for deployment injury surveillance during current Army deployments in support of OIF and OEF. From this surveillance and analysis, NBI occurrences, rates, types, anatomical locations, and causes were reported for 2001 to 2006. Clear from this analysis, NBIs were the most important cause of medical evacuations. The leading causes of NBI in OIF and OEF were similar to those for past

conflicts and many should be preventable. Routine injury surveillance conducted during OIF and OEF has allowed early detection of injury rates, types, and causes, and should allow commanders and Army leaders to focus attention on prevention countermeasures and policies while the operations are on-going.

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CHAPTER 4

USE OF ACCIDENT REPORTS TO IDENTIFY OPPORTUNITIES FOR PREVENTION: EXAMPLES FROM THE U.S. AIR FORCE SAFETY CENTER

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4-1. USING SAFETY DATA TO DESCRIBE COMMON INJURY-PRODUCING SCENARIOS: AN EXAMPLE FROM THE U.S. AIR FORCE

A. INTRODUCTION.

(1) The U.S. military leaders have historically valued a thorough understanding of the causes and circumstances associated with the mishaps that generate unintentional injuries of the highest levels of severity, particularly fatalities. Fortunately, the frequency, or incidence, of these injury-producing mishaps is low in both absolute terms and relative to the more frequent and less severe mishaps/injuries down at or near the base of the injury pyramid. Safety investigations of the less severe mishaps such as those producing only lost duty time (that is, not fatal and not disabling) are not as rigorous or detailed as investigations of those mishaps that produce injuries of greater severity (Class A and Class B). This information limitation along with the enormity of possible injury-producing scenarios has resulted in a less complete understanding of the causes and circumstances behind those injuries towards the pyramid's base. However, from a total injury burden perspective, the lost workday injuries (LWIs), which are mostly Class C, represent approximately 96 percent of that burden.

(2) In 2003, the military Service branches were directed to reduce their mishaps by 50 percent within 2 years.⁽¹⁾ This target has since been increased to a 75 percent reduction by the end of 2008. To achieve material reductions in the overall injury burden as the directives mandated, it became obvious early on that an exclusive focus on the Class A/B segment of the pyramid, at the pinnacle, would fail to achieve the overall mass reduction. To prevent the more frequently occurring unintentional injuries, it has become necessary to understand the events that produce them. Therein lays the rationale for undertaking an ambitious and novel endeavor to systematically analyze this large volume of injury-producing mishaps. Adding to the degree of difficulty, this information was needed in an expeditious manner since the clock was running.

C. The first, high-level analysis was completed in May 2003 with the second part—detailed prevention information—completed by November 2003. This section will provide the methods for both efforts, but the Results below will reflect some of the findings from the Part I analysis. Selected Part II results, the hazard scenarios, will be shown in the companion sections of this chapter.⁽²⁻⁵⁾ The hazard scenario defines the victim, the source of injury, the environment and the task.⁽⁶⁾ A hazard scenario can be developed for different events and used as an organizing mechanism. According to Drury and Brill, to be useful: (1) a maximum of six scenarios should account for more than 90 percent of the mishap events; (2) for each scenario, at least one apparently feasible and effective intervention could be applied; (3) each scenario is mutually exclusive of others; and (4) each scenario has human factors as a major parameter.⁽⁶⁾

B. METHODS.

(1) STUDY CRITERIA.

(A) Fiscal Years (FY) 1993–2002 ground mishap report information was extracted, both coded data elements and narrative text information, from the Ground Safety Automated System (GSAS). The GSAS is a Web-enabled application used by the 300-plus safety offices throughout the U.S. Air Force (USAF) to report mishaps to the Air Force Safety Center (AFSC). As such, this system may be considered as an event and injury surveillance system serving a demographically unique community (Table 4-1-1) typical of contemporary military populations. The Air Force Safety Automated System (AFSAS) also functions as an occupational injury surveillance system for civilian employees, a decidedly older population (data not shown). Mishaps in this database met Department of Defense (DOD) reporting requirements at the time of the event, the primary one being that the injuries sustained in the mishaps are unintentional. Although GSAS allows data retrieval of mishaps back to 1971, the current study analyzed data from 32,812 reports from the 10-year period 1993–2002.

TABLE 4-1-1. DEMOGRAPHIC PROFILE, U.S. AIR FORCE ACTIVE DUTY FOR 1998, THE MIDPOINT OF THE 1993–2002 STUDY PERIOD

Age Group	Personnel	Percent Male	Percent Enlisted
17-24	108,982	75%	95%
25-34	141,614	83%	77%
35-44	100,926	87%	75%
45+	11,673	85%	30%

(B) Reporting rules are contained in DOD Instruction 6055.7⁽⁷⁾ that can be viewed in its entirety at <http://www.dtic.mil/whs/directives/corres/pdf/605507.pdf>. In short, the reporting threshold for each class of injury-producing mishaps is—

- (1) Class A—fatality or permanent total disability.
- (2) Class B—permanent partial disability.
- (3) Class C—injury causing loss of 1 or more days away from work beyond the day or shift it occurred, or injury causing a permanent change of job.

(C) Flight safety mishap data were excluded from this study because the existing coding of these electronic reports did not clarify which person(s), among several individuals associated with a multi-person mishap, sustained the lost workday injuries. The exclusion of flight mishap data undercounted LWIs by an estimated 1 to 2 percent at most.

(D) The analysis also excluded fatal injuries in which death was immediate or when a person was medically retired shortly after an injury, leading to a prognosis of imminent death or certain permanent disability. In these rare situations, the total accumulation of lost workdays (LWDs) would have been zero, or the mishap not reported at all given that the victim was no longer on Active Duty when death occurred. Those injuries in which duty days were lost before the person died were included in this analysis (n = 10). This selection criteria resulted in a dataset that was overwhelmingly classified as Mishap Class C, not the immediately fatal (Class A) or disabling (either Class A or Class B) mishaps.

(E) Military personnel assigned to the Air Force Reserves Command (AFRC) or Air National Guard (ANG) were also excluded from the analysis since their narrative reports were less detailed and would have generated considerable missing data for the scenario reconstructions. This categorical exclusion assumed that all such unit assignments were valid indicators of the component (that is, Active Duty, ANG, AFRC) where that person actually belonged. As an example, an Airman assigned to an AFRC or ANG unit was assumed not to be an Active Duty component troop merely assigned to that unit, or vice-versa. This assumption was not valid in all cases, but these situations were the exception, not the rule. No other reliable method existed to precisely differentiate between an individual's component and his/her unit's command of assignment in order to allocate person-time appropriately for rate calculations used in the internal report of these results.

(F) The following extraneous categories of personnel were systematically excluded from this study: cadets, foreign nationals, Youth Opportunity Program workers, non-U.S. military, non-Air Force military, and contractors. Injuries in those groups would either be nonreportable according to Federal law or a group for which the USAF is not officially accountable. Mishaps and injuries occurring during Basic Military Training were recorded in another data system not linked to the safety reporting system for the operational USAF; thus, those injuries were not included in this analysis. The study did, however, include both Department of the Air Force civilian employees and military paid from nonappropriated funds.

(G) For military personnel, both on- and off-duty mishaps and injuries were included in the database. Off-duty civilian employee mishaps are not reportable; thus, those injuries are not in the GSAS database. As such, the field of reported injuries for civilian employees is generally of occupational etiology in the broadest sense. However, data presented in this paper did not necessarily reflect official classification and reporting of occupational injuries. Many USAF civilian injuries in the database were incidental to paid work duties specific to occupations. As an example, there were numerous slips and falls in the parking lot or on sidewalks going to and from the various workstations. A breakout for occupation-unique "industrial injuries" is not presented here. Thus, data on civilians shown here were a combination of incidental and industrial since they were officially reported to GSAS as occupational.

(2) MISHAP CLASSIFICATION, CODING, AND EVENT RECONSTRUCTION.

(A) In preparation for the intricate event reconstruction, already-coded broad data elements were used from the safety database (that is, category, subcategory, and activity) to group mishaps along the lines of the International Classification of Diseases, 10th revision (ICD-10) classification system. Examples of categories as defined in GSAS are motor vehicle, sports and recreation, and ground industrial. Once grouped into those ICD-like categories (such as, falls from one level to another), a taxonomy unique to each of those categories and, subsequently, descriptive hazard scenarios with potential interventions or solutions was developed for each. Since the ICD-10 system is ill-suited for describing injuries occurring within sports and recreation mishaps and injuries, more detailed lists of activity-specific-hazard scenarios were created. This three-step process consisted of reading each mishap narrative and developing a standard descriptive phrase (hazard scenario), tabulating and determining the most common scenarios, and adjusting scenarios to be more or less inclusive or exclusive as necessary. Considerable judgment was involved in this iterative process to realize the goals of (1) minimizing the number of unique scenarios by finding their commonality in three to four different aspects/elements while (2) preserving enough detail to deliver relevant and robust prevention information. We operated on the premise that although every mishap is unique, the aggregation of scenarios based on similar characteristics was necessary to achieve a substantial degree of commonality. Without this aggregation, a burden of dozens of scenarios so unique that an intervention targeted at any one scenario would have prevented too few injuries to substantially reduce the overall injury burden.

(B) To quantify the impact of these injuries on readiness, duty days lost, injuries, and days lost per injury were totaled to rank them within each category (either an activity or a mechanism). Military and civilian employee injuries were assessed both individually and combined. To be consistent, both the mean and the median number of days lost per injury were calculated in every category since the frequency distribution of several categories of injuries was severely right-skewed due to a limited number of extremely high values for days lost.

(C) To expand the analysis of certain injury mechanisms, coded database elements such as age, rank, civilian/military status; number of lost duty days; injury class; body part injured; nature of injury (e.g., fracture or sprain/strain); functional duty area; and other descriptors were used. Off-duty mishaps were not classifiable by duty area; however, that designation was included in data tables for perspective. The injured body part coding was recoded to remove the “sidedness” (left or right) of an injured limb, appendage, eye, or ear. While a person’s sex is available from GSAS, males and females were not analyzed separately. Such an analysis was outside the scope of the analyses that originate from this report. Given that about 80 percent of the USAF is male and male unintentional injury rates are significantly higher than females, the body of mishaps and injuries included in this series is predominantly male.

(D) The most prominent hazard scenarios were placed into tables by their frequency ranking within those same categories and broken down into military and civilian employee categories. The tables are not exhaustive, as space and time limitations prevented us from showing all but the major generators of injuries.

(E) In this particular section, the top generators of LWIs categorized by both activity and injury mechanism (external cause) were identified. This presentation was limited to activities or mechanisms that produced at least 3,000 total lost duty days. Falls from stairs and ladders in the slips, trips, and falls (STF) category were included within the activity tables, but that subcategory of falls is also shown separately within the mechanism data tables. As such, the STFs shown in the activity tables are the only exception to the mutually exclusive categorization and presentation scheme. The rationale for the stairs/ladders breakout is the widespread reliance on ladders and ladder-like appliances in USAF activities, not only in generic tasks (such as, physical plant maintenance) but also in aircraft-related functions. Examples of these functions are aircraft maintenance and repair, inspection, cleaning, painting, weapons (off) loading, configuration of cargo compartments, flight crew and passenger (de)boarding, and refueling. Hazard scenarios for the activities and injury mechanisms presented here are described elsewhere in this chapter.⁽²⁻⁶⁾

(F) The percentage of activity, or mechanism-specific injuries resulting in fractures, was used as a surrogate for injury severity. While injuries of higher severity were reported, their numbers were negligible and sometimes at odds with standard medical classifications/definitions for such injuries. Fractures were more easily and consistently classified by GSAS reporters, and they represented a field of significant injuries that produced higher numbers of lost duty days per injury than, for example, sprains or strains.

C. FINDINGS. Military and civilian USAF personnel incurred 32,812 lost duty day injuries during the 10-year period. A total of 22,249 injuries were reported on USAF military personnel, accounting for 171,202 lost duty days. The lost-duty-day total for this group accounted for 67 percent of the Total Force (military and civilian employee) burden of 254,507 LWDs. Civilian employees lost a total of 83,392 workdays in 10,563 injuries. The primary cause of the disproportionate reporting is due to the nonreportable nature of off-duty civilian employee injuries. When subtracting the off-duty injuries (n = 18,375) from the military total, that sector's lost duty time dropped sharply to 24,861 duty days compared to the civilian employee total of 83,392 LWDs (data not shown).

(1) MILITARY ANALYSIS.

(A) Operating vehicles (such as, personal, rented, or government-maintained) and equipment generated reported LWDs and total LWIs over three orders of magnitude higher than the second-ranked activity, riding in or on vehicles or equipment (such as, passengers/riders, not operators) (Table 4-1-2). Injuries sustained while participating in sports and recreational activities accounted for most of the remaining injuries. The percentage of reported injuries that resulted in fractures ranged from 24 percent for basketball injuries to 60 percent for dirt biking/all-terrain vehicle (ATV) use. The fifth-ranked activity for producing LWIs was climbing or descending stairs or ladders. Injuries sustained while operating vehicles/equipment (OVE), or riding in or on them, typically (93 percent) occurred in off-base mishaps involving personally owned motor vehicles (data not shown). Injuries for sports/recreational activities typically occurred on the military installation except for trail riding/dirt biking that was over 80-percent off base.

TABLE 4-1-2. PREDOMINANT ACTIVITIES AND INJURY MECHANISMS GENERATING LOST DUTY DAYS IN U.S. AIR FORCE ACTIVE DUTY PERSONNEL, SHOWING THE TOTAL LOST WORKDAYS, TOTAL REPORTED UNINTENTIONAL INJURIES, AND MEAN/MEDIAN DAYS LOST PER INJURY, PERCENTAGE THAT WERE FRACTURES, AND PERCENTAGE OCCURRING ON BASE, 1993–2002

Rank	Activity or Mechanism	Total LWDs	Total Injuries Reported	LWDs Per Injury: Mean/Median	Percent Fractures	On-Base Percent
<i>Activity</i>						
1	OVE	46,818	4,390	10.7/3	31%	13%
2	Riding in or on vehicles or equipment	13,023	1,147	11.4/4	33%	16%
3	Playing basketball	12,520	2,165	5.8/2	24%	78%
4	Climb/descend stairs or ladder	6,902	965	7.2/3	44%	59%
5	Playing softball	6,843	1,171	5.8/3	44%	71%
6	Trail riding—dirt bike/ATV	5,563	454	12.3/7	60%	8%
7	Playing flag football	5,406	939	5.8/3	36%	74%
<i>Mechanism</i>						
1	STF ^a	20,646	2,997	7.2/3	31%	60%
2	Struck object/ struck by object	5,208	932	5.6/2	22%	73%
3	Lifting/carrying object ^b	3,386	1,231	2.8/2	3%	72%

Notes:

^a Excludes sports and recreation falls. Major activity breakdown: climbing or descending stairs and ladders (see Table 4-1); walking (n = 2,363); stepping up or down to/from uneven surfaces (n = 380); entering/exiting buildings or vehicles (n = 368); carrying items (n = 254); handling or carrying items/equipment (n = 155); running not associated with jogging, sports, or training (n = 138).

^b Does not include injuries resulting from being struck by objects that the person had dropped, or pedestrians injured by motor vehicles while carrying an object.

(B) Sports and recreation injuries are more notable for their LWD frequency than their contribution to the injury total (Table 4-1-2). In general, this field of activities had fewer extreme values for the number of days lost, resulting in lower mean LWDs per injury than injuries from other activities. Median values for LWDs per injury were relatively consistent, usually from 2 to 3 lost days, owing to the suppressed influence of the outlying values. After reducing that effect, dirt biking and riding ATVs still showed a median of 7 lost days per injury and a mean value of 12.3 days per injury.

(C) The top lost workday injury mechanism was STFs with over 20,000 total LWDs stemming from nearly 3,000 injuries (Table 4-1-2). Nearly one-third of these reported mishaps included a fracture and most (60 percent) occurred on base. Being struck by an object or vehicle, or striking an object or vehicle, was the second most frequent injury mechanism, but with only about one-fourth of the lost workday injury total as STFs. Lifting or carrying an object or person was the remaining major contributor with 3,386 total LWIs, but the mean and median number of

lost days per injury were both low and relatively equal, indicating that few of these injuries resulted in large number of LWDs. Only 3 percent of injuries from this mechanism were fractures (most were sprains/strains, data not shown). While 60 percent of STFs occurred on base, the other two major mechanisms were even more likely to have occurred on base.

(D) Injured Airmen were most likely to have been assigned to aircraft maintenance functional/work areas, accounting for 6 percent of all LWIs (Table 4-1-3). However, those 1,289 LWIs paled in comparison to the off-duty domain where over 18,000 injuries occurred, or 82 percent of the lost workday injury total. Table 4-1-3 should be interpreted with caution, as an Airmen's assigned functional area does not indicate the environment in which the mishap occurred. A medical person sustaining an injury while operating or riding in an ambulance would, for instance, have contributed to the medical/health services functional area, not transportation.

TABLE 4-1-3. PREDOMINANT FUNCTIONAL AREAS OR DOMAINS GENERATING LOST DUTY DAY UNINTENTIONAL INJURIES IN U.S. AIR FORCE ACTIVE DUTY PERSONNEL WITH INJURY TOTALS AND PERCENT GENERATED BY DUTY AREA, 1993–2002

Rank by Total Injuries	Functional Duty Area	Number LWD Injuries	Percent of Reported Injuries
1	Military off-duty	18,250	82%
2	Aircraft maintenance	1,289	6%
3	Civil engineering	546	2%
4	Security	365	2%
5	Combat training	222	1%
6	Operations	207	1%
7	Communications/computer operations	186	1%
8	Supply/logistics	185	1%
9	Transportation	170	1%
10	Medical/health services	137	1%

Note: Totals do not add up to 100 percent as 4 percent fell into several miscellaneous areas.

(2) CIVILIAN EMPLOYEE ANALYSIS.

(A) Climbing, working from, or descending stairs or ladders was the work activity that produced the most LWIs in civilian employees (Table 4-1-4) versus being the fourth-ranked category in military personnel. This activity was a subset of the STF injury mechanism which produced over 38,000 LWDs from over 4,000 lost workday injuries. The operating vehicles/equipment were the second-ranked civilian activity but only produced about one-fifth of the total LWDs and injuries as stairs/ladders. Both the mean and median lost days per injury were, however, higher than all other activities even though only 14 percent of the injuries were fractures. A secondary analysis, not shown, revealed that most (56 percent) of the civilian OVE injuries were incurred while operating special purpose vehicles or motorized equipment such as aircraft tugs or forklifts. This contrasts with the military OVE injuries in which 93 percent

occurred while operating motor vehicles, usually personally owned. The civilian OVE injuries were not exclusively on-base incidents, as 27 percent of those occurred off the military installation, generally hauling cargo or operational crews (such as, missile launch control officers). The remainder of the civilian activities was, with the exception of riding in/on vehicles or equipment, unlike the field of predominant military activities: handing or manipulating objects, using hand tools, and using power equipment. The proportion of civilian injuries that produced fractures was significantly lower than military activities of similar ranking.

TABLE 4-1-4. PREDOMINANT ACTIVITIES AND INJURY MECHANISMS GENERATING LOST WORKDAYS FOR U.S. AIR FORCE CIVILIAN PERSONNEL, SHOWING THE TOTAL LOST WORKDAYS, TOTAL REPORTED UNINTENTIONAL INJURIES, MEAN/MEDIAN DAYS LOST PER INJURY, PERCENT FRACTURES, AND PERCENT OCCURRING ON BASE, 1993–2002

Rank	Activity or Mechanism	Total LWDs	Total Injuries Reported	LWDs Per Injury: Mean/Median	Percent Fractures	On-Base Percent
<i>Activity</i>						
1	Climbing/descending stairs or ladders	10,469	1,083	9.7/4	20%	99%
2	OVE	2,217	190	11.7/5	14%	73%
3	Handling/manipulating objects, general	1,314	186	7.1/3	<1%	99%
4	Riding in/on vehicles or equipment	1,056	100	10.6/4	24%	78%
5	Using hand tools	1,040	165	6.3/3	<1%	100%
6	Using power equipment	683	88	7.8/4	<1%	100%
<i>Mechanism</i>						
1	STF ^a	38,062	4,334	8.9/4	19%	98%
2	Lifting/carrying object ^b	21,454	2,854	7.5/4	<1%	99%
3	Struck object/struck by object	6,090	998	6.1/3	16%	99%
4	Dropped object (hit by)	1,441	245	5.9/3	23%	99%

Notes:

^a Major activity breakdown: climbing or descending stairs and ladders (10,469); walking (n = 1,619); entering/exiting buildings or vehicles (n = 263); stepping up or down to/from uneven surfaces (n = 238); carrying items (n = 170); handling or carrying items/equipment (n = 88); sitting on a chair or stool (n = 87).

^b Does not include injuries resulting from being struck by objects that the person had dropped, or pedestrians injured by motor vehicles while carrying an object.

(B) Almost all of the top civilian injury-producing mechanisms occurred on base (Table 4-1-4). The STF and lifting or carrying objects (or people in some circumstances) were the top two injury mechanisms. Severity overall was not particularly high as evidenced by the low to moderate proportion of injuries that were fractures. However, those top two categories each generated an additional LWD per injury (measured by median days lost) compared to the last two categories. Almost three out of four civilian injuries occurred to individuals working in three areas: aircraft maintenance; services/Morale, Welfare and Recreation (MWR); and civil engineering (Table 4-1-5).

TABLE 4-1-5. PREDOMINANT FUNCTIONAL AREAS GENERATING LOST DUTY DAY UNINTENTIONAL INJURIES IN U.S. AIR FORCE CIVILIAN EMPLOYEES WITH INJURY TOTALS AND PERCENT GENERATED BY DUTY AREA, 1993–2002

Rank by Total LWDs	Functional Work Area	No. Lost Duty Day Injuries	Mean/Median LWDs Per Injury	Percent of Reported Injuries
1	Aircraft maintenance	3,311	7.2/3	31%
2	Services/MWR	2,243	7.3/3	21%
3	Civil engineering	2,085	9.0/4	20%
4	Other	821	8.4/3	8%
5	Supply/logistics	513	7.5//3	5%
6	Transportation	308	8.8/5	3%
7	HQ/base command and administration	207	8.9/4	2%
8	Medical services	184	9.7/4	2%
9	Communications/computer operations	172	9.7/4	2%
10	Personnel	159	7.4/3	2%

D. DISCUSSION.

(1) METHODOLOGICAL ISSUES.

(A) Using a systematic approach, the predominant lost workday injury-producing activities and mechanisms were determined in both Airmen and civilian employees. That the methodological framework used here also originated independently in another group of injury researchers speaks to the appropriateness of this method for using data from enterprise safety reporting systems. The data presented here is but a first-level perspective, rather than the detailed hazard scenario information that the methodology and GSAS data facilitated. That information—the true value of these findings—is presented separately in this chapter.⁽²⁻⁵⁾

(B) Even though the data elements specified by Lincoln, et al.,⁽⁸⁾ were not used in all cases, we advocate for obtaining as many of these elements as is feasible for injury prevention work. First, researchers cannot know *a priori* which of the data elements may offer complete information. In addition, the value of each data element often changes when researchers move from one activity or mechanism to another. For example, in going from “hit or hit by object” mishaps to “fall on same level” mishaps, the value of the object data element is obviously reduced. Also, while a particular data element may be highly desired by the research team, it is possible that neither the coded data nor the narrative information on that element will be sufficiently complete or detailed to enable a useful recreation of the incident. In that event, a secondary data element may stand in as a competent alternative descriptor. So, having the flexibility to include or exclude specific data elements is an analytical advantage.

(C) A secondary benefit of developing the complete taxonomy in the event reconstruction is that, when viewing it in matrix format (such as, in a spreadsheet), researchers can easily

visualize the data gaps and recommend improvements in the data collection scheme. However, perhaps the most compelling reason for acquiring as many data elements as possible becomes evident when a very narrow field of injuries is being analyzed. Lincoln et al.,⁽⁸⁾ looked specifically at 1,585 back injuries in military truck drivers for developing their taxonomy, so having relatively precise details of the hazard scenarios—of which a finite number of them exist for this type of injury—was advantageous. This analysis of over 30,000 injuries without such restrictions required a dynamic incorporation of only a fraction of the available data elements in any one activity or mechanism in order to achieve aggregating large numbers of mishaps. This was made possible by having a wide array of data elements from which to draw.

(D) The methods for coding, classifying, and reconstructing mishaps closely resembled those methods developed and described elsewhere by Lincoln et al.⁽⁸⁾ This work was published about a year after this work concluded. In short, they used U.S. Army safety data to develop event reconstruction syntax and taxonomy drawn from both coded and narrative data from the Army's reporting system that operates under the same rules as the USAF. The goal of event reconstruction was, like Lincoln et al., to find hazard scenarios generating relatively large numbers of mishaps, each potentially preventable using the same scenario-specific interventions. While this parallel system was not developed as fully or as systematically as Lincoln et al., the basic framework correlated well with their model.

(E) The data elements for the Lincoln et al., event reconstruction methodology consisted of broad activity (such as, maintenance work), task (such as, inspecting engine), contributing factor (such as, greasy hands), precipitating mechanism (such as, slip), injury event/exposure (such as, fall from elevation), primary source (such as, hard surface), secondary source (such as, vehicle bumper), nature of injury (such as, contusion), and outcome (such as, number of LWDs).⁽⁸⁾ Except for the secondary source, all of those data elements were used at some point in the scenario development, but no single injury grouping ever encompassed more than five of those data elements.

(F) Consistent with what Lincoln et al.,⁽⁸⁾ found with the Army data, the information needed for a full descriptive taxonomy was often found in the rich narrative/text information, not from the coded data elements. Since many of the desired data elements did not exist in the GSAS database structure, coding each mishap was required for systematic creation/reconstruction hazard scenarios. This event reconstruction was sometimes done within an activity—particularly for sports and recreation injuries—or by injury mechanism for industrial injuries. For the industrial injuries, the hazard scenario itself describes the detailed motion or action being performed at the time of the injury (such as, while climbing a ladder), while the sports/recreation activity (such as, playing basketball) is broken down further in order to deliver targeted prevention information. The top-level data tables presented alternate between showing activities and injury mechanisms depending on the circumstances of the mishap and the amount

of data available. An attempt was made to place each injury in the context that would provide the best information for injury prevention.

(2) CONTEXTUAL ISSUES REGARDING AFSAS DATA.

(A) The USAF safety mishap data are generated from a Web-based mishap reporting system intended for prevention purposes. This type of system differs markedly from the administrative data systems from which military enterprise medical data are derived. In such systems, every transaction (medical encounter) is recorded without any threshold for doing so. Despite the seemingly complete ascertainment of medically treated injury cases, this type of data has limited utility for determining injury causes and mechanisms that enable interventions. On the other hand, safety data cannot be used to estimate complete injury incidence since the reporting thresholds (at the time of this study, minimum of a LWD) preclude injuries at the bottom of the injury pyramid—most frequent but lowest in severity—from being reported. The act of reporting can itself impose another filter on the total incidence picture since supervisors and managers have to notify base safety officials who, in turn, have to investigate the mishap and subsequently write and submit the report.

(B) As with any passive surveillance system, as is common to public health practice, breakdowns in such processes are expected to occur. By one estimate,⁽⁹⁾ only 53 percent of seemingly reportable injuries in the USAF—those recorded in inpatient medical data—are reported via GSAS. Regardless of the extent of incomplete reporting, GSAS is sufficiently complete for prevention policy development, as are many national passive surveillance/reporting systems in the disease prevention realm. The value of such systems is obviously not for full enumeration of cases/injuries but rather for their depth of information that results from the investigation and analysis. For GSAS, this depth enables an understanding of injury causes and circumstances that is far beyond that of medical data. The totality of reported mishaps is best characterized as a large representative sample of moderate to severe injuries that met the reporting threshold. These injuries are the most operationally important ones to reduce; thus, the data on these events are particularly valuable to preserve manpower.

(C) While the USAF's mishap reporting and injury surveillance system is tantamount to a "community-based" system of the same, this Service's demographic profile is starkly different from any general population outside the military environment. As Table 4-1-1 indicates, the Active Duty forces are predominantly young adult males. The female minority is also young and, like males, about three-quarters enlisted. As such, the findings from this section of the report and the companion studies on Airmen are generalizable only to a likewise young adult, healthy, physically active civilian population. Given that this demographic niche is any population's highest risk group for unintentional injuries, the findings from these studies should be useful for a deeper understanding of injury mechanisms. Despite the military setting, these injuries could just as easily have occurred in nearly any community, as off-duty injuries

dominated the picture. The civilian employee findings are, on the other hand, most representative of a stable middle-age industrial cohort. While the USAF's industrial sector is aviation-centric in many ways, the range of occupational specialties is vast. Thus, these injuries possibly represent a cross-section of occupational injuries in the non-Defense sector.

(3) EMPIRICAL FINDINGS AND INTERPRETATION.

(A) There are few surprises in the top activities generating LWIs in Airmen since this population is generally young and active. However, the degree of contribution from dirt bike and ATV trail riding is surprising as this type of recreation is relegated to a relatively small group of enthusiasts who may consider this as their hobby. Thus, their exposure time may be greater and more intense than that of sports such as basketball or softball that have mass participation and appeal. Furthermore, the level of kinetic energy to be discharged during mishaps is obviously higher than sports and hobbies that do not involve motorized vehicles.

(B) Except for trail riding, about three-quarters of the sports and recreation injuries occurred on base but not necessarily on duty. Injuries occurring during the duty day are officially classified as "on-duty" for legal line-of-duty determination; however, for the purposes of this analysis, given that no Airmen's principal job is to play a sport regardless of the time or location, they were categorically labeled as "off-duty". It was recognized that some exceptions probably occurred (such as, training for inter-service tournaments and perhaps some unit training), but the vast majority was likely to be purely recreational in nature.

(C) The top activities and mechanisms for injuries to Airmen were consistent with medical data,⁽⁹⁾ with vehicle operation/riding and STFs dominating their respective fields. Of note is the large difference between the two measures of central tendency (mean and median) for the number of days lost per injury in these categories. The higher mean value indicates that severe injuries occur down at the base of the injury reporting pyramid (that is, from Class C mishaps). Therefore, Class C should not necessarily be equated with low severity. Also, the finding that 60 percent of all STFs in Airmen occur on base should not be interpreted as the on-base environment being excessively hazardous. In the USAF, a significant proportion of Airmen live on the base, so their off-duty activities are included in the on-base fraction. Bases provide ample facilities for off-duty Airmen to engage in a number of sports and fitness that can produce injuries.

(D) The high percentage of Active Duty injuries that resulted in fractures are an artifact of the threshold for reporting injuries, and it can likely be assumed that most injuries are less medically significant and, thus, fall below the reporting threshold. These percentages do, however, demonstrate that LWIs are operationally and clinically significant regardless of their Class C status.

(E) The lower severity of civilian employee injuries may be explained by several potential factors. First, there are comparatively few reported injuries sustained while operating or riding in or on vehicles, situations that can discharge vast amounts of kinetic energy and result in extended disability. Also, civilian employees may be more practiced in performing certain tasks as most have been doing their line of work for many years. At any given point in time during the study period, the age of that work force was somewhere in the mid-forties. Unlike Active Duty personnel who may advance (get promoted) out of manual labor in a few years, it is not uncommon for civilians to practice their craft their entire careers. Experienced workers are generally safer workers as well, so perhaps their exposure to hazardous situations is buffered by this advantage. Finally, the age of the workforce may contribute a proportionately greater percentage of sprain/strain injuries than what Active Duty Airmen generate.

(F) A key consideration for the injury reduction mandate is the degree of control that the USAF has over the circumstances surrounding the injury-producing mishaps. About four of every five LWIs to Airmen occur off duty, and this presents a dilemma for which easy solutions do not exist. Conversely, activities and mechanisms that are predominantly on base in their occurrence represent the best opportunity for direct intervention.

(G) A secondary analysis (not shown) reveals that Active Duty industrial injuries, as reported through GSAS, occur at a very low frequency that continues to decline. Yet, enough of these injuries continue to occur that they too represent viable injury reduction targets, particularly in the aircraft maintenance and civil engineering sectors. Civilian employee injuries occur in those same functional areas along with Services/MWR, a sector that represents a variety of disparate job settings (such as, childcare centers, fitness centers, and food service operations). Many of these were STFs and offer an area in need of further study.

(H) The STF injuries are second only to the vehicle/equipment-related injuries in their contribution to the Active Duty LWIs problem. On the civilian employee side, this mechanism is the primary one to assess more fully, as is done in the remainder of this chapter. While most (60 percent) of the military injuries are on base and/or industrial, the remainder occur off the installation. Unlike motor vehicle-related mishaps, off-base STF injuries to Airmen can occur multiple ways and in the most commonplace circumstances. Thus, these may be more resistant to USAF control than motor vehicle mishaps. Of course, the fatality rates are higher for the latter so those should continue to receive a considerable share of the attention. While the Active Duty transportation/vehicle-related mishap problem has received significant attention, it should be noted too that civilian injuries in the transportation functional area have generated the highest median LWDs per injury: 5 days. This indicates that the severity of these injuries is substantial, and, thus, another viable target for injury reduction.

E. SUMMARY. This descriptive study of LWIs used novel methods to disclose hazardous scenarios for a wide array of circumstances. The methods and data model of Lincoln et al.,⁽⁸⁾

were demonstrated to be robust, in that they were appropriate for a more broad-based analysis. No analysis of this genre has been done previously in the USAF; thus, those scenarios shown in the rest of this chapter⁽²⁻⁵⁾ provide valuable insight on how to prevent injuries occurring in specific circumstances. This specificity will enable more efficient targeting of safety programs and initiatives, and perhaps increase the effectiveness of some existing programs. Only through more specific targeting of prevention activities can the military expect to appreciably reduce the burden of LWIs.

F. REFERENCES.

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4-2. LIFTING, HANDLING, AND CARRYING: OBJECTS ASSOCIATED WITH INJURY IN ACCIDENT REPORTS.

A. INTRODUCTION.

(1) Over the past decade, the Annual Survey of Occupational Injuries and Illnesses performed by the U.S. Department of Labor, Bureau of Labor Statistics (BLS) has consistently reported overexertion to be a leading cause of lost workday injuries (LWIs) in private industry.⁽¹⁾ From 1993–2002, overexertion injury was also the leading cause of lost workdays (LWDs) among U.S. workers for 8 of the 10 years.⁽¹⁾ In the 2003 BLS survey, specifically, overexertion accounted for 26 percent of all injuries and illnesses, with overexertion while lifting accounting for 55 percent and overexertion while handling and carrying accounting for 13 percent of the overexertion injuries.⁽¹⁾ The BLS defines overexertion as an injury that resulted from excessive physical effort directed on an external source of injury. The physical effort may involve lifting, pulling, pushing, turning, wielding, holding, carrying, or throwing the source of injury. As a result, it is not surprising that material handlers and occupations with high physical workloads have been found to be at high risk for overexertion back injuries.⁽²⁻⁴⁾

(2) Numerous studies have attempted to identify the many factors involved in back pain to include physical, psychosocial, social, demographic, and occupational.⁽⁵⁻¹⁰⁾ However, no studies of lifting-handling-carrying injuries among military personnel, many of whom have very physically demanding jobs, have been conducted. This section focuses on LWDs resulting from injuries due to overexertion while lifting-handling-carrying objects. This injury category excludes injuries categorized as slips, trips, and falls (STFs) that were also associated with lift-handle-carry (LHC) events.

(3) The present study is part of a larger descriptive epidemiologic study conducted by the U.S. Air Force Safety Center (AFSC) to focus greater attention on, and reduce the number of, LWIs in the United States Air Force (USAF). This study is distinct in that the focus is not on identifying hazard scenarios (mechanisms) but rather objects associated with the injuries. Since the hazard scenarios associated with LHC injuries were very similar, identifying objects was deemed more important for the identification of detailed cause information necessary for development of effective countermeasures.

B. METHODS.

(1) Detailed methods for developing and identifying hazard scenarios are presented in Section 4-1.⁽¹¹⁾ In short, LHC injury data for the fiscal years (FYs) 1993–2002 was obtained from the U.S. Air Force's (USAF) ground mishap reporting system, the Ground Safety Automated System (GSAS). This study uses GSAS, a detailed USAF mishap reporting database to characterize LHC injuries, and to identify the activities, objects, and occupational groups most

often associated with these injuries. Lifting-handling-carrying is defined as an application of significant directional force against an object. The GSAS data from 1993–2002 were analyzed and grouped by mechanism. The GSAS contains safety reports on military personnel (on and off duty) and on-duty Department of Defense (DOD) civilian personnel who experience a nonaviation or ground-related mishap. Civilian injuries are reported only if they occur on base, or if occurring off base when the employee is in a paid status. Off-duty injuries are only reportable for Active Duty personnel.

(2) The initial step in this process was categorization of the injury-producing mishaps by mechanism after reading the one-liner and/or full mishap report narrative as necessary. Since a list of common objects had not previously been developed in GSAS, the list was formulated by aggregating similar objects and continually refining the list to capture the greatest number of objects. Since many objects were characterized using different levels of specificity, some degree of judgment was used during this process. Frequencies are presented for LWIs, LWDs, age, occupation, and circumstances (such as, object lifted/handled/carried, time of day), and injury outcomes (such as, severity as measured by LWDs, injury type) related to LHC injuries. Frequencies and crude injury rates are presented for military and civilian USAF personnel separately. For calculating military crude rates, person-year contributions were used without exception: every airman contributed fully to the denominator (that is, one person equals 1 year of occupational exposure time). Age and occupation specific rates were not calculated as reliable denominator figures were not available. Given that approximately 80 percent of the USAF is male and male unintentional injury rates are significantly higher than female rates, the mishaps and injuries included in this report are predominately males.⁽¹¹⁾

C. RESULTS.

(1) Among USAF military and civilian personnel, LHC activities generated 4,085 LWIs, producing 24,940 LWDs. The LHC activities ranked third overall in both the number of LWIs and LWDs. However, LHC injuries were concentrated in the civilian workforce. When considering the civilian and military workforces separately, LHC activities were the second leading cause of civilian injuries and total workdays lost (Table 4-2-1), with 2,854 total LWIs (16 injuries per 10,000 worker-years) and 21,454 total LWDs. For the military, with a total of 1,231 LWIs (3.3 injuries per 10,000 worker-years) and 3,386 LWDs, LHC ranked fourth for injuries and tenth for total workdays lost (Table 4-2-2). On-duty military activities accounted for 724 LWIs (1.9 injuries per 10,000 worker-years). The LHC injury frequency continually declined over the 10-year period with a 68-percent and 60-percent reduction in the civilian and military workforces, respectively, but the number of civilian injuries was still twice those of military personnel in FY 2002 (Figure 4-2-1). Examining on-duty injuries only, the frequency of LHC injury reports declined 50 percent in the Active Duty population, but the number of reported LHC injuries in the civilian population was three times greater in FY 2002. The combined percentage of LHC injuries occurring on base was 90.8 percent (99 percent civilian

and 72 percent military). In the Active Duty force, off-duty LHC activities accounted for 502 or 41 percent of LHC LWIs.

TABLE 4-2-1. TOP 10 EXTERNAL CAUSES OF LOST WORKDAYS (RANKED BY TOTAL LOST WORKDAYS), U.S. AIR FORCE CIVILIAN PERSONNEL, 1993–2002^a

Rank	Activity	Total LWDs	Total LWIs	LWDs Per injury: Mean/Median
1	STF ^b	27, 593	3,251	8.5/4
2	LHC ^c	21, 454	2, 854	7.5/4
3	Climb/descend stairs or ladders	10, 469	1, 083	9.7/4
4	Struck or struck by object	6, 090	998	6.1/3
5	OVE	2,2 17	190	11.7/5
6	Dropped object (hit by)	1, 441	245	5.9/3
7	Handling	1, 314	186	7.1/3
8	Riding in/on vehicles or equipment	1, 056	100	10.6/4
9	Using hand tools	1, 040	165	6.3/3
10	Using power equipment	683	88	7.8/4

Notes:

^a Total LWIs and LWDs were 10,563 and 83,392, respectively, for all activities/external causes.

^b Includes various activities, but specific well-defined activities (e.g., playing basketball, softball, or climbing a ladder or stairs) were included in those more specific categories, not included in this general STF category.

^c Not included in this category are injuries categorized as STF that were associated with the acts of LHC.

TABLE 4-2-2. TOP 10 EXTERNAL CAUSES OF LOST WORKDAYS (RANKED BY TOTAL LOST WORKDAYS), U.S. AIR FORCE ACTIVE DUTY PERSONNEL, 1993–2002^{a,b}

Rank	Activity	Total LWDs	Total LWIs	LWDs Per injury: Mean/Median
1	OVE	46,818	4,390	10.7/3
2	STF ^c	14,554	2,032	7.2/3
3	Riding in/on vehicles or equip	13,023	1,147	11.4/4
4	Playing basketball	12,520	2,165	5.8/2
5	Climb/descend stairs or ladders	6,902	965	7.2/3
6	Playing softball	6,843	1,171	5.8/3
7	Trail riding—dirt bike/all-terrain vehicle (ATV)/Quad	5,563	454	12.3/7
8	Playing flag football	5,406	939	5.8/3
9	Struck/struck by object	5,208	932	5.6/2
10	LHC ^d	3,386	1,231	2.8/2

Notes:

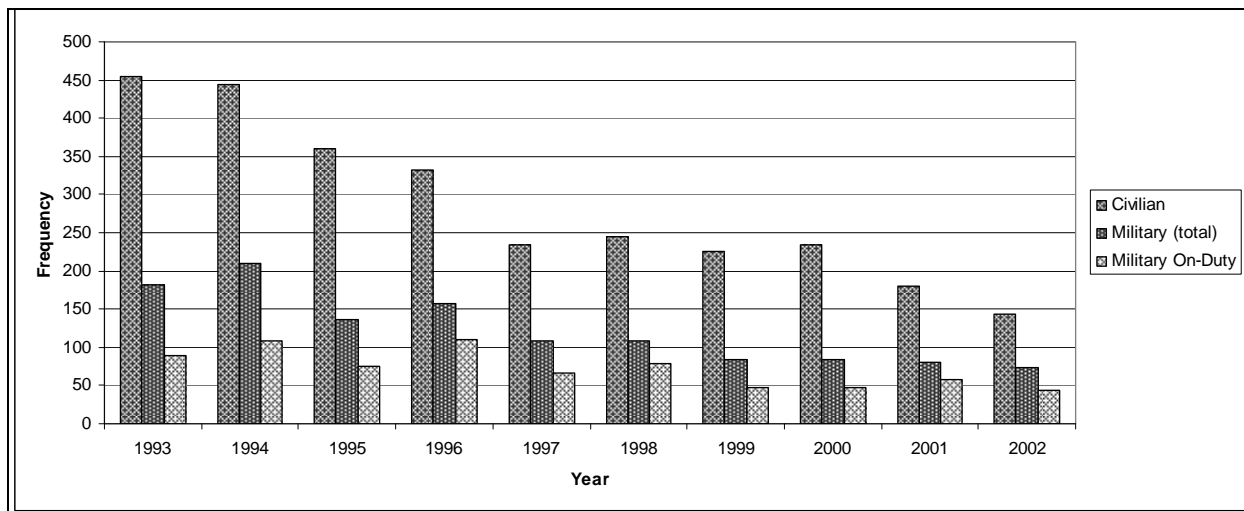
^a Total LWIs and LWDs were 10,563 and 83,392, respectively, for all activities/external causes.^b Includes both on and off-duty mishaps.^c Includes various activities, but specific well-defined activities (e.g., playing basketball, softball, or climbing a ladder or stairs) were included in those more specific categories, not included in this general STF category.^d Not included in this category are injuries categorized as STF that were associated with the acts of LHC.

FIGURE 4-2-1. FREQUENCY OF LIFTING-HANDLING-CARRYING INJURIES REPORTED TO AIR FORCE SAFETY CENTER HEADQUARTERS BY YEAR AND EMPLOYMENT STATUS, FY 1993–2002

(2) Civilian LHC injuries were primarily concentrated in those 35 years and older; whereas, injuries in the military population were concentrated in those less than 35 years of age (Figure 4-2-2). The percentage of injury reports coded as back injuries declined with age (Figure 4-2-3). The high percentage of back injuries under age 45 was heavily influenced by the age

distribution of the military population. Although the civilian workforce had more than twice the number of LHC injuries, a larger proportion of the younger Active Duty population's LHC injuries were to the back (Figure 4-2-3). The age distribution of LHC injuries prevailed regardless of the object being handled, with one notable exception, the lifting or carrying of a child, primarily in a childcare center. For childcare workers, the highest frequency of injury reports occurred in the 25–34 age group, reflecting the younger age distribution of employees at the childcare centers, where 67 percent of injury reports for childcare workers originated.

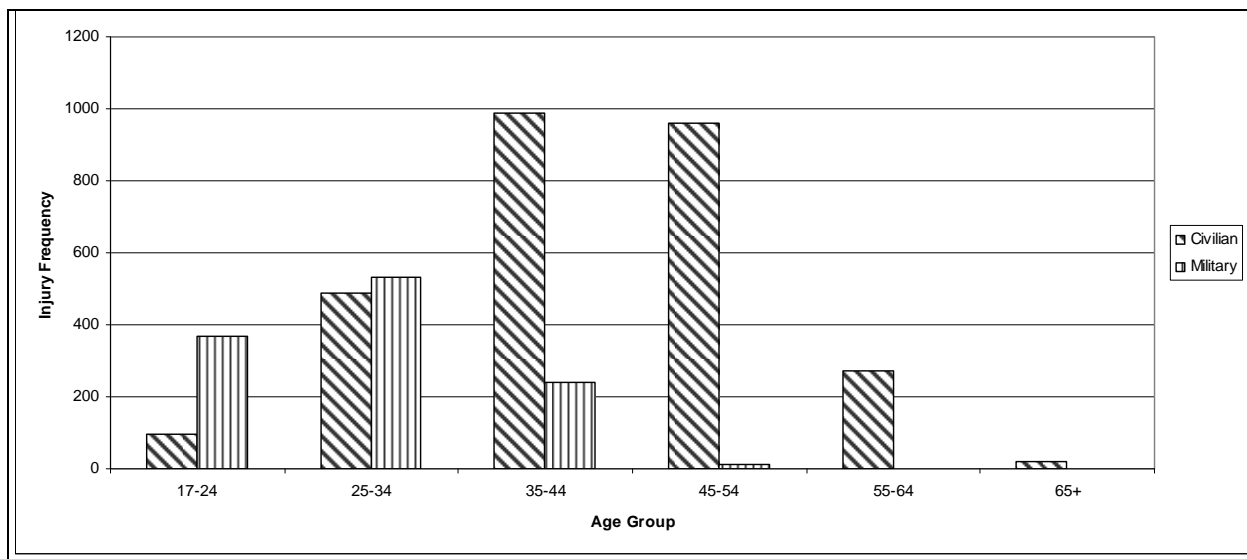


FIGURE 4-2-2. FREQUENCY OF LIFTING-HANDLING-CARRYING INJURIES REPORTED TO AIR FORCE SAFETY CENTER HEADQUARTERS BY AGE GROUP (MILITARY VERSUS CIVILIAN), FY 1993–2002

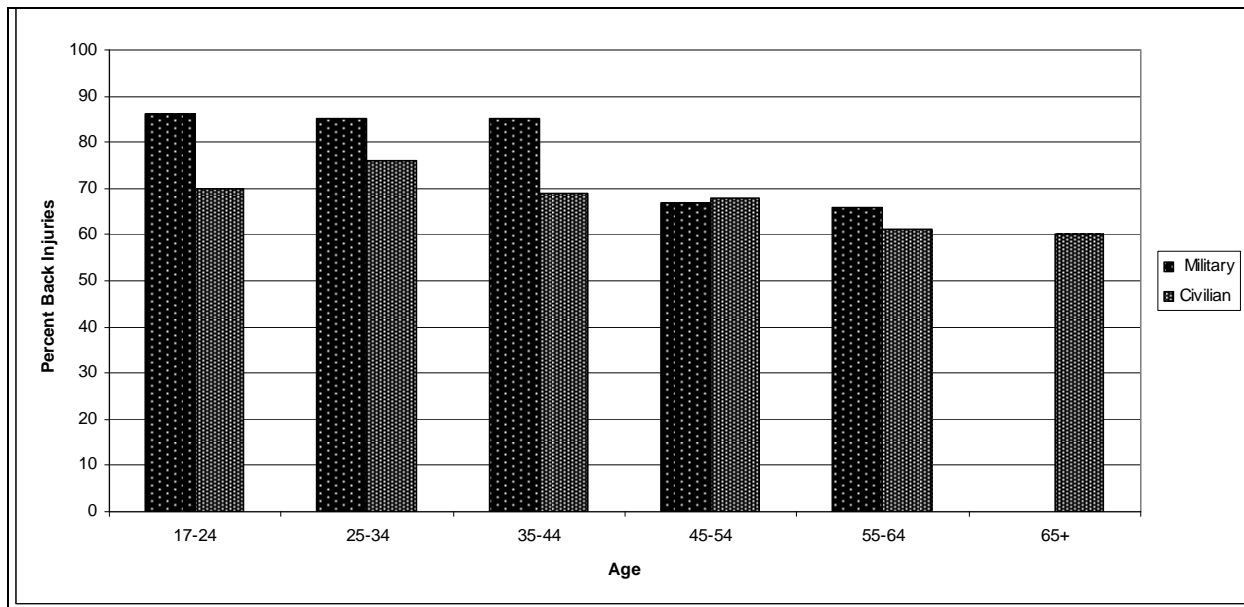


FIGURE 4-2-3. PERCENTAGE OF LIFTING-HANDLING-CARRYING INJURIES REPORTED TO AIR FORCE SAFETY CENTER HEADQUARTERS CODED AS BACK INJURIES BY AGE GROUP (MILITARY VERSUS CIVILIAN), FY 1993–2002

(3) A large disparity between military and civilian also occurred in the severity of injuries, as measured by LWDs (Tables 4-2-1 and 4-2-2). In the civilian workforce, LHC injuries produced a mean of 7.5 and a median of 4.0 LWDs per injury, while generating a mean of 2.8 and median of 2.0 LWDs per injury in the military workforce. The leading nature of injury in both the civilian and military populations was strains (87 percent). Of these strains, 74 percent were to the back; in the military workforce, 1,037 (84 percent) injury reports involved a back injury versus 1,968 (69 percent) for civilians.

(4) Analysis of time of day (data not shown) showed that LHC injuries largely occurred during the typical duty hours of 0700–1600 with a steady surge occurring through the morning hours with the frequency peaking at 1000-1059 hours, just prior to the lunch hour, possibly suggesting that workers were tiring after several hours of exertion.

(5) An examination of objects associated with on-duty LHC injuries revealed aircraft components to be the largest contributor to on-duty LHC injuries (Table 4-2-3). Aircraft components were responsible for 1,176, or 33 percent of all on-duty military and civilian LHC injury reports. This was most evident in the Active Duty population where 54 percent of LHC injuries involved aircraft components.

TABLE 4-2-3. COMMON OBJECTS ASSOCIATED WITH ON-DUTY LIFTING-HANDLING-CARRYING INJURIES, U.S. AIR FORCE MILITARY AND CIVILIAN PERSONNEL, 1993–2002

Object	Example	LWIs (% of total)
Active Duty Members^a		
Aircraft components	Lifting aircraft tail Excludes: Removing engines	393 (54%)
Boxes (loaded)	Lifting boxes of MREs Excludes: Lifting boxes of files	60 (8%)
Furniture (office)	Moving office desk Excludes: moving computer equipment	51 (7%)
Bag/sack (loaded)	Loading/carrying sandbags Excludes: filling sandbags	32 (4%)
Toolbox	Lifting toolbox Excludes: pushing loaded tool cart	30 (4%)
Civilian Employees^b		
Aircraft components	Lifting ECM pod Excludes engines	783 (27%)
Boxes (loaded)	Lifting boxes of auto parts Excludes: boxes of paper files	286 (10%)
Furniture (office)	Moving computer desk Excludes: moving computer equipment	193 (7%)
Civilian Employees^b		
Child	Lifting from crib Positioning baby Excludes: pushing baby in stroller	110 (4%)
Stand	Moving maintenance stand	92 (3%)
Cart/dolly	Pulling battery cart	81 (3%)
Door/hatch	Pushing hanger door	74 (3%)
Engines/transmissions Gearboxes	Pulling engine Lifting pump motor onto truck Excludes: pushing engine stand with engine on it	68 (2%)
Boxes of paper	Carrying printer paper Lifting files	57 (2%)
Computer equipment	Lift/carry PC to new cubicle	51 (2%)

Notes:

^a Table limited to activities causing 3 or more LWIs per year (total: 724 LWIs).^b Table limited to activities causing 5 or more LWIs per year (total: 2,849 LWIs).

(6) When LHC injuries were assessed by occupation (data not shown), it was found these injuries largely impacted aircraft maintenance workers. The LHC injuries represented 29 percent of all civilian aircraft maintainer injuries and 21 percent of military maintainer injuries. The overwhelming majority of maintainer injuries occurred to the back, with 81 percent and 65 percent of military and civilians, respectively, reporting back injuries.

(7) Handling of furniture and boxes made a significant contribution to the overall frequency of LHC injuries, generating 750 reports, or 18 percent of all military and civilian LHC associated injury reports (Table 4-2-3). The frequency of on-duty injury reports for civilians was

more than four times that for Active Duty. Handling furniture/boxes was the most common cause of off-duty LHC injuries in Active Duty personnel, accounting for 160 (32 percent) lost workday injuries.

D. DISCUSSION.

(1) For FY 1993–2002, injuries sustained by LHC objects ranked third overall in the number of LWIs in the USAF military and civilian personnel. The LHC injuries were concentrated in the civilian workforce, ranking second only to injuries sustained while operating vehicles or equipment. Although LHC injuries ranked fourth overall in producing lost workday injuries in the Active Duty force, they were the leading cause of occupationally related injury in the military workforce. The USAF ranking of LHC injuries is consistent with estimates reported by the U.S. Department of Labor for private industry employers where exertion injuries have consistently ranked first in the number of lost workday injuries.⁽¹⁾

(2) Although LHC events were the second leading cause of civilian LWDs, there was a 68 percent decline in these injuries from FY 1993–2002. The frequency of military LHC injuries subsided 60 percent from FY 1993 to 1998, but the frequency remained unchanged from 1999–2002. The decline in the frequency of LHC injuries was likely influenced by the personnel drawdown in the early 1990s. During the study period, the Active Duty force was reduced approximately 14 percent; whereas, the civilian workforce was reduced 25 percent. Although the frequency of LHC injury reports to the AFSC declined over the 10-year period, analysis of AFSC data indicate the crude Active Duty occupational injury rate trend remained flat; in contrast, the crude civilian occupational injury rate experienced a significant decline (AFSC, unpublished data).

(3) The greatest number of civilian LHC injuries was reported in workers aged 35 or older; whereas, the military workforce had the fewest number of injury reports in this age category. This distribution can be attributed to the overall age distribution of the civilian workforce where most are in the 35+ age category. The low number of military injuries in this age category is reflective of the movement of career Airmen away from the industrial functions into administrative functions as they progress through the ranks.

(4) One exception to the civilian age distribution involves injuries to childcare workers. Injuries occurred more frequently in the 25–35 age group. Of the 159 injuries associated with lifting or carrying a child, 67 percent occurred at an on-base daycare center. This younger age distribution is attributed to the younger ages of childcare workers. These reports are consistent with that reported in a study of childcare workers in Minnesota where the mean age of injured childcare workers was 32, 50 percent of those injured were under 29 years, and lifting a child was associated with 49 percent of the total injuries.⁽¹²⁾

(5) The number of LWDs per injury was greatest in the civilian workforce where the median number of lost days was 4.0, versus 2.0 in the Active Duty force. The older age distribution in the civilian workforce may account for the increased number of LWDs as the older worker may require a longer recovery time. Although there appears to be a disparity in the severity of injury between the civilian and military workforces, USAF workers (both military and civilian) lost fewer workdays per injury than private sector workers. The BLS survey data over the same time period reveals that the median number of LWDs for overexertion due to lifting or carrying ranged from 6–9 days. The predominate injuries, in both the USAF and private industry workforces, were strains where the overwhelming majority occurred to the back.

(6) Back injuries are a leading cause of LWDs, workers' compensation claims, and disability.⁽¹³⁾ In 1996, low back pain accounted for nearly 15 percent of all claims and almost 55 percent of indemnity costs.⁽⁵⁾ In 1999, the estimated rate of workers' compensation claims for back injury was 58 per 10,000 workers covered.⁽⁶⁾ Occupations with high physical workloads have been shown to be associated with increased reports of back pain and other musculoskeletal injuries. Many of the occupational activities involve LHC. Numerous studies have attempted to identify the many factors involved in back pain including physical, psychosocial, social, demographic, and occupational.⁽⁵⁻¹⁰⁾ One study estimated that 37 percent of low back pain worldwide is due to occupational factors.⁽¹⁴⁾ An analysis from the 1990 Ontario Health Survey estimated 25 percent of back pain to be related to physical occupational workloads.⁽¹⁵⁾ Data from the U.S. National Health Interview Survey revealed the prevalence of work-related LWD back pain was 4.6 percent resulting in over 101 million LWDs.⁽¹⁶⁾

(7) Back injuries were highly associated with USAF LHC injuries; overall, 74 percent of LHC injuries involved the back. Zwerling et al., examined risk factors among older workers and found that mechanics, repairers, and those with heavy lifting requirements were at increased risk for occupational injury.⁽¹⁷⁾ This analysis revealed a steady decline in the percentage of injuries involving the back as workers aged; regardless of the steady decline in back injuries with age, the percentage of back injuries in the oldest age group was still 60 percent. Other studies have indicated that younger workers, and those with less experience on the job, were more susceptible to low back injury.⁽²⁻⁴⁾

(8) In 2003, the BLS survey identified the back as the body part most affected (184,850 injuries) by overexertion events.⁽¹⁾ The most common source of overexertion injury was handling containers. Material handlers have been found to be at high risk for overexertion back injuries. One study of material handlers in a home improvement retail business reported a rate of 4.25 per 100 full-time equivalents for low back injuries; these rates were similar across age groups, even when considering length of employment and lifting intensity.⁽²⁾ A study of home improvement store workers found injury rates to be highest among employees under 25 years of age with time on the job of less than 2 years and with the greatest lifting and handling requirements.⁽³⁾ Another study of retail merchandise material handlers reported injury rates

similar to the previous study in those workers with the greatest physical work requirements. However, the rate for workers with lesser requirements was half that of workers with the greater physical requirements. Those who had a short duration of employment were more than 3.5 times likely to suffer a back injury.⁽⁴⁾

(9) Ostbye et al., found that body mass index had a strong effect on occupational injury claims and LWDs, and this effect was strongest in occupations most associated with lifting.⁽¹⁸⁾ Similarly, Pollack et al., found that traumatic workplace injuries increased with increasing body mass index, and this association was greatest for acute sprains/strains.⁽¹⁹⁾ These findings could further explain the discrepancy between civilian and military workers. Military workers are generally younger, with most being removed from industrial functions before the age of 40 and are less likely to have excess body mass as they must maintain a prescribed level of fitness. Although the Active Duty force suffers fewer overall reportable injuries with fewer lost days per injury and has lower occupational injury rates, it is of interest to note that the overwhelming majority of injuries from LHC events were to the back. It is possible that the younger, more physically fit, Active Duty workforce tends to be overconfident in their physical capabilities, employing less caution and paying less attention to proper lifting techniques.

(10) Aircraft components were the leading cause of on-duty LHC injuries in both military and civilian workforces. However, aircraft components affected a greater proportion of military personnel (54 percent). In contrast, loaded boxes and furniture affected equal proportions of both military and civilian workers. Given the impact aircraft components had on LHC injuries, aircraft maintenance functions were ranked first in producing the number of LWIs and LWDs for both civilian and on-duty military injuries. The LHC injuries represented 29 percent and 21 percent of the total injuries to civilian and military aircraft maintenance workers, respectively.

(11) This discrepancy is probably influenced by the fact that military maintainers spend less time over their careers performing the industrial functions of the job. As military members progress in rank, they are moved into supervisory positions or assigned other collateral duties; whereas, the civilian counterparts will perform the “hands-on” industrial functions throughout their career. Furthermore, the civilian employee is entitled to workers’ compensation benefits, and, thus, is provided an added incentive to report occupational injuries that could potentially influence the discrepancy between military and civilian LHC injury rates.

(12) Off-duty activities accounted for 502 LWIs in the Active Duty population. This figure is likely to be greatly underestimated. It is dependent upon the victims notifying their supervisors as to the cause of their injury and the supervisors initiating a mishap report, which in-turn, is investigated by safety personnel. Handling furniture and loaded boxes were the two highest off-duty LHC injury-generating activities. This finding has significance in that the Active Duty military can be expected to make numerous household moves during a career, placing them at higher risk for exposure and resulting injury. Even though moving contractors

are hired to move household goods, the Active Duty military can be expected to move furniture and boxes between rooms when resettling. When assessing the combined exposure of both on and off duty, handling of furniture and boxes made a contribution second to only aircraft components, which affects primarily aircraft maintenance technicians. Handling of furniture/boxes affects a much broader population making targeted interventions more difficult.

(13) Prevalence estimates have revealed that unstructured workplaces tend to have the highest risk occupations, such as construction workers, nursing aides, and building supply retailers.^(10, 20-21) Many of the USAF workplaces are unstructured where workers perform a variety of tasks making prevention more challenging. The highest risk-functional area was found to be aircraft maintenance workers handling aircraft components. To achieve a significant reduction in LHC LWIs, more preventive measures should be focused on the aircraft maintenance-functional area. Aggressive preventive measures should be implemented and existing policies enforced. Preventive measures should include use of mechanical lifts and comprehensive training on use of lifts, manual lifting techniques, and assessment of procedures and lifting requirements of various maintenance tasks.

(14) Collins et al., conducted an intervention trial of an LHC prevention program implemented in six nursing homes to assess the reduction of musculoskeletal injuries in a high-risk group.⁽²²⁾ The implementation of mechanical lifts, a written “zero lift” policy, and improved training significantly reduced injury rates caused by resident handling for first-time injury reports, workers’ compensation claims, and reportable injuries on Occupational Safety and Health Administration reporting logs, regardless of age or job experience at all sites studied. Similar approaches to reducing LHC induced musculoskeletal injuries should be implemented in high-risk areas throughout the USAF in an effort to achieve further reductions in overexertion injuries. Ergonomic guidelines are available to assist workplace supervisors in instituting safer methods and policies for material handling.⁽²³⁾ Efforts to reduce off-duty LHC injuries would appear to be more challenging, but more education in proper lifting techniques and perhaps moving equipment (such as, dolly and so forth) could be made available to those transitioning or planning to move bulky objects. Back injuries are multifaceted and caused by physical workload and psychosocial, social, demographic, and occupational factors. Prevention strategies should take into consideration all factors whenever possible.⁽¹⁰⁾ The USAF employees may be considered at high risk for injuries because of the variety of high-risk tasks and locations. Broader prevention efforts should incorporate efforts in promoting greater job control and health promotion in the civilian workforce.⁽¹⁰⁾

E. KEY POINTS.

- (1) Safety data provides mishap details valuable to forming countermeasures.
- (2) LHC injuries in USAF personnel are predominately found in civilians in the 35-55 age group.
- (3) Lifting aircraft components causes the majority of reported injuries in both military Active Duty and civilians within the USAF.
- (4) Additional countermeasures to prevent LHC injuries in aircraft maintenance workers are warranted.

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4-3. SLOW PITCH SOFTBALL: MECHANISMS OF INJURY FROM ACCIDENT REPORTS.

A. INTRODUCTION.

(1) According to the National Electronic Injury Surveillance System, sports- and recreation-related injuries comprised 16 percent of all unintentional injury-related emergency department visits in the period July 2000–June 2001. Furthermore, softball and baseball were among the leading causes of injury in age categories 20-24, 25-44 and >45.⁽¹⁾ Softball has also been ranked as one of the leading team sports associated with injury hospitalizations,⁽²⁾ injuries among senior officers,⁽³⁾ and lost man-days⁽⁴⁾ in the U.S. Army. Although no accurate participation levels are available, U.S. Air Force (USAF) softball participation rates are most likely higher than the general U.S. population and similar to U.S. Army rates due to a younger population who are encouraged to be physically active. Typically, every squadron sponsors a team and every USAF base has multiple softball fields.

(2) Literature specific to softball injury prevention is sparse. Case reports focus on rare events, such as ball throwers fracture of the humerus⁽⁵⁾ and traumatic hyphema.⁽⁶⁾ Several articles categorize mishaps by injury type,⁽⁷⁻⁹⁾ or systems such as neurological injuries.⁽¹⁰⁾ Some studies of softball injury have attempted to define the mechanism of injury.^(4, 11-15) However, only prospective studies were able to give any information on mechanism,^(12, 13, 15) with Nadeau's retrospective study being the exception to the rule.⁽¹¹⁾ The common thread in all of these studies is that they are based on medical data, which result in either small numbers, a lack of detail necessary for targeted prevention, or both. A systematic review of interventions to prevent softball-related injuries identified a need for studies describing the cause of softball injuries.⁽¹⁶⁾

(3) The present study uses a large, detailed mishap reporting (safety) database to fill the gap present in the literature regarding the different mechanisms of injury in adult slow-pitch softball. This section reports on a subset of results, specific to organized softball, that are part of a larger effort of the U.S. Air Force Safety Center (AFSC) to focus on nonfatal injury prevention and to better understand the nature of lost work injuries (LWIs) among USAF personnel.

B. METHODS. The terms “hazard scenario” and “mechanism” were considered roughly interchangeable; they differ mainly in use by area of interest (medicine versus safety). In this article, the term mechanism is used. Detailed methods for developing and identifying mechanisms are elsewhere in this report.⁽¹⁷⁾ In short, Ground Safety Automated System (GSAS) data from 1993–2002 were analyzed and grouped by activity—this section specifically describes slow pitch softball. The GSAS contains safety reports on the USAF Active Duty population—which is young, predominately male, and physically active. Descriptive statistics (such as, frequencies, distributions) were produced for a wide variety of factors, such as fiscal year, age, major command, functional area, injury type, and activity. Within each injury activity, descriptive mechanisms were developed that would potentially inform prevention efforts. Since

a list of mechanisms had not previously been developed in GSAS, the list was formulated using a systematic and time-intensive process of reading reports (one-line descriptions and narratives as necessary), aggregating similar mishaps, and continually refining the list to capture the greatest number of mishaps. The final list of eight mechanisms (Table 4-3-1) captured 89 percent of the mishaps that occurred during the study period. Gender was not a factor in this study since female participation was extremely limited. Since the proportion of Active Duty USAF personnel involved in softball activities is unknown, only frequencies of mechanisms are presented (rates could not be calculated).

TABLE 4-3-1. FREQUENCY OF OBSERVED SCENARIOS PRODUCING SOFTBALL INJURIES AND POTENTIAL PREVENTION MODALITIES, ACTIVE DUTY U.S. AIR FORCE PERSONNEL, 1993–2002

Mechanism	Example(s)	Injuries Reported^a (%)	Prevention
Sliding	- Slid into second - Slid into third base face first - Excludes: Stepping on base, running between bases	272 (23%)	- Breakaway bases - Ban sliding - Restrict headfirst sliding - Two home plates
Hit by ball	- Struck on jaw by ball - Hit in left eye by ball - Excludes: Stepped on ball	236 (20%)	- Helmet, face guard wear at all times - Reduced injury factor balls
Collision with player	- Collided with another player - Run over by another player - Excludes: Sliding, running	187 (16%)	- Training to “call balls” to warn off other fielders - Two home plates
Running	- Tore Achilles tendon running - Running and knee buckled under - Excludes: Sliding, collision, falling	126 (11%)	- Pre-season conditioning - Shift emphasis from stretching to warming up prior to play
Fall, unspecified	- Fell and landed on elbow - Running and fell - Excludes: Sliding, running w/out fall	81 (7%)	- Training to improve balance - Improved fields
Stepped on: base, bat, ball	- Stepped on base - Tripped over base - Excludes: Sliding, falling	57 (5%)	- Recessed bases
Diving or jumping	- Jumped and twisted back - Dove for ball and dislocated elbow - Excludes: Sliding	52 (4%)	- Training to improve balance - Recognize this isn’t the Majors!
Swinging bat	- Swung bat and twisted knee - Swung bat and strained back - Excludes: Stepped on bat	34 (3%)	- Pre-game warm-up - Conditioning

Note: ^a Total softball-related LWIs reported to the AFSC, 1993–2002 = 1,171.

C. RESULTS.

(1) Sports and recreation injuries comprised 25 percent of all reported LWIs, with 5 of the top 12 activities from the sports and recreation category (Table 4-3-2). With 1,171 total lost workday injury reports, softball ranked eighth overall, second only to basketball in total number of injuries within the sports and recreation category. However, it climbed to fifth overall in total injuries and sixth in total lost workdays (LWDs) when only military reports are summarized (Table 4-3-2).

TABLE 4-3-2. TOP 10 ACTIVITIES ASSOCIATED WITH LOST WORKDAY INJURIES REPORTED TO THE AIR FORCE SAFETY CENTER, ACTIVE DUTY U.S. AIR FORCE PERSONNEL, 1993–2002^a

Rank	Activity	Total LWIs	Total LWDs	LWDs Per Injury	On-Base Percent
1	Operating vehicle/equipment (OVE)	4,390	46,818	10.7 / 3	13
2	Basketball	2,165	12,520	5.8 / 2	78
3	Slips, trips, and falls (STF) ^b	2,032	14,554	7.2 / 3	61
4	Lifting/carrying (non-STF)	1,231	3,386	2.8 / 2	72
5	Softball	1,171	6,843	5.8 / 3	71
6	Riding in/on vehicles or equipment	1,147	13,023	11.4 / 4	16
7	Climb/descend stairs or ladder	965	6,902	7.2 / 3	59
8	Flag football	939	5,406	5.8 / 3	74
9	Struck/struck by object ^c	932	5,208	5.6 / 2	73
10	Trail riding—dirt bike/ All-terrain vehicle (ATV)/Quad	454	5,563	12.3 / 7	8
	Total	15,426	120,223		

Notes:

^a Excludes categories such as “standing,” which conveys only incidental activities.

^b Numerous activities were associated with this category but specific, well-defined activities (e.g., STFs due to playing basketball or softball or climbing a ladder or stairs) were included in those more specific categories rather than being included under this general STF category. Activity breakdown: general walking (n = 2,363); stepping up or down from/to uneven surfaces such as curbs (n = 380); entering/exiting buildings or vehicles (n = 368); carrying items (n = 254); while handling or carrying items or equipment (n = 155); running—not associated with sports, jogging, or physical training (n = 138); and dozens of other activities.

^c Does not include persons being stuck by objects that they dropped; being struck by a dropped object is categorized here as lift/carry/handle; also, does not include being hit by a motor vehicle (pedestrian injuries are included in lower frequency categories not included in this table).

(2) Softball-related LWIs declined over time, from 190 LWIs in 1993 to 90 LWIs in 2002. Although decreasing in total number and frequency for much of the last decade, a plateau was reached in 1999 (Figure 4-3-1). Since almost all of the total injuries for other activities have decreased in a similar trend during this period, the decrease is probably due to the drawdown in Active Duty Service members rather than from the implementation of any countermeasure.

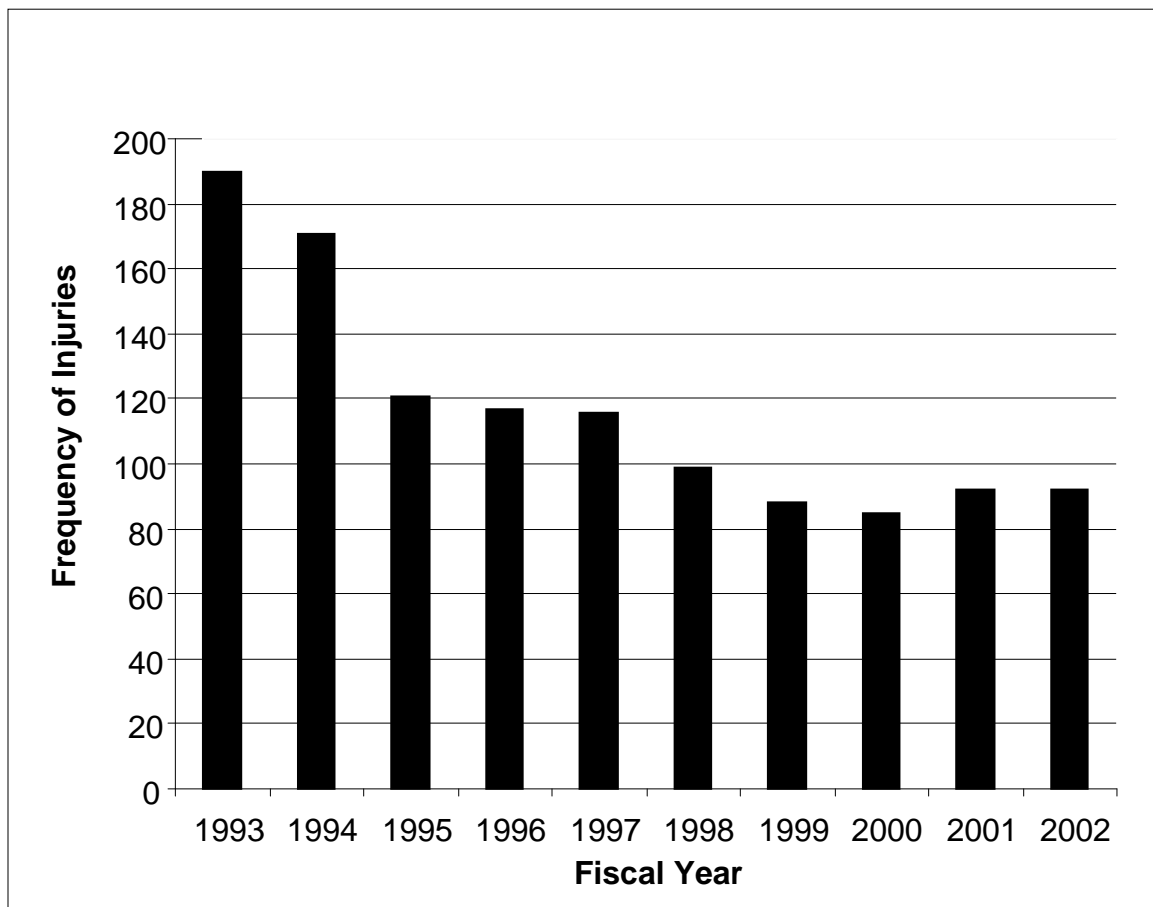


FIGURE 4-3-1. FREQUENCY OF SOFTBALL-RELATED LOST WORKDAY INJURIES REPORTED TO THE AIR FORCE SAFETY CENTER HEADQUARTERS, FY 1993–2002

(3) Table 4-3-1 summarizes the 1,171 softball injuries reported by mechanism. Only three mechanisms (that is, sliding, hit by ball, and collision) represent 60 percent of the injuries. Prevention measures to reduce sliding-related injuries include use of breakaway bases, banning sliding, restricting headfirst sliding, and use of two home plates. Prevention measures to reduce hit-by-ball injuries include use of a helmet and face guard at all times and use of reduced injury

factor balls. Prevention measures to reduce collision-related injuries included training to call balls and use of two home plates.

D. DISCUSSION.

(1) As seen in other civilian and military populations, softball is a leading cause of LWIs among USAF personnel. Since sports—specifically softball—generate a large proportion of the LWIs in the USAF, injury prevention efforts can no longer focus solely on occupational injuries. Softball’s popularity, presence on base, and the availability of proven interventions present numerous opportunities for injury reduction.

(2) These data also show that, among USAF personnel, sliding, hit by ball, and collisions represent 60 percent of the softball injuries. Much attention has deservedly been placed on sliding. Janda has reported 52 of 73 (71 percent) injuries were caused by sliding in a retrospective review of community and hospital records.⁽¹⁸⁾ Nadeau has previously reviewed three summers of emergency room records related to softball injuries at Yokota Air Base and found 45 percent were caused by sliding.⁽¹¹⁾ A 1-year prospective study of orthopedic referrals found 42 percent of softball injuries were due to sliding.⁽⁴⁾ A prospective study of collegiate baseball and softball players found that softball produced a higher rate of sliding injuries than baseball and, in softball, headfirst slides resulted in a higher injury rate.⁽¹²⁾ A prospective study comparing standard and breakaway bases found that 3 percent of all slides released the breakaway base and that breakaway bases dramatically reduced sliding injuries.⁽¹³⁾

(3) Several reviews of softball injury have attempted to define the mechanism of softball injury. Janda reasons that softball injuries can be grouped into three categories: sliding, collisions, and falls. He does provide data supporting sliding as the primary mechanism, but does not provide substantiating data for collisions and falls.⁽¹⁴⁾ In a later paper, overuse injuries is added to make the list more comprehensive.⁽¹⁵⁾ Nadeau uses 150 emergency room visits and finds that 82 percent fall into the same 3 categories of sliding, collisions (both players and balls), and falls.⁽¹¹⁾ Wheeler uses 100 referrals to find the mechanisms of sliding, jamming, and falls.⁽⁴⁾

(4) The common thread in all of these studies is that they are based on medical data, which result in either small numbers, a lack of detail necessary for targeted prevention, or both. Only prospective studies were able to give any information on mechanism,^(12, 13, 15) with Nadeau’s retrospective study being the exception to the rule.⁽¹¹⁾ One study of military officers, who sustained injuries during an advanced training course, reviewed medical records but was not able to obtain information on mechanism and called for more information to be reported by providers.⁽³⁾ This is further illustrated by a study that described sports and physical training injuries in the U.S. Army that used hospital admissions, since they identify the activity, while outpatient visits do not.⁽²⁾ This is a good start for identifying problem areas but is lacking in

providing the mechanism. A systematic review of interventions to prevent softball-related injuries identified a need for studies describing the cause of softball injuries.⁽¹⁶⁾

(5) This study attempts to overcome problems found in medical data, such as lack of detailed history of the injury, small sample size, short periods of observation, and focus on selected causes (sliding) or type of injury (fractured humerus) to describe all of the mechanisms of softball injury in the USAF.

(6) External cause coding is usually only available in the medical record for hospitalized cases. Although this information is valuable for describing the most serious of injuries, it only captures a small percentage of the total injuries. Furthermore, cause coding for sports and recreation events, such as softball, does not give specific information regarding mechanism, which is necessary for developing effective countermeasures. Whether or not a more detailed cause-coding scheme should be developed to capture the mechanism is a dilemma faced by the civilian sector. This dilemma is further complicated if it increases the burden of already heavily tasked medical providers. The military has the advantage of having safety offices at every installation charged with investigating mishaps, thereby, providing the necessary data without relying on the medical community.

(7) If the civilian community decides to further develop cause coding to include mechanism for sports and recreation activities, the military safety database would be an excellent source of information. As these data show, the historical record of hundreds of detailed accounts of softball injuries provide the necessary information to aggregate and identify the most common mechanisms.

(8) Safety reports are also more commonly initiated for hospitalized cases; however, they also capture a large number of outpatient visits. In the present study, 912 (78 percent) of the 1,171 reports were outpatient visits. This increased number of reports allows greater visualization of all the mechanisms present, such as running and stepping on objects, rather than just sliding and collisions. This list of eight mechanisms, rather than the three used by Janda⁽¹⁴⁾ and Nadeau,⁽¹¹⁾ gives important information for developing countermeasures. For example, it allows separation of the category of collision into collision between players from a player hit by a ball, which have very different countermeasures.

(9) Underreporting of injuries in the safety data is the principle limitation of this study. Currently, the reporting process relies on a chain of events with a number of weak links: the injured player notifying the supervisor, the supervisor notifying safety, the safety office investigating the mishap, and finally, reporting to the AFSC. Various estimates of underreporting have varied from 50 percent to 90 percent underreporting (AFSC, unpublished data). However, although not random, reports have been shown to be a valid sample of all injuries. In conclusion, medical records, such as emergency room visits, give important

information for estimating the burden of injury and type of injury, but valuable details for prevention is missing. Conversely, due to underreporting and established thresholds for reporting, safety data does not provide an accurate picture of the total burden but is invaluable in providing detailed information necessary to establish countermeasures to reduce injury. Both data sources are necessary to fully understand the magnitude of the injury problem in the U.S. military and how leading causes of injuries can be mitigated.

(10) Although sliding is the most common mechanism, it has been occurring at a lower proportion in the USAF than in other populations. The high frequency of the hit-by-ball scenario is surprising since the common perception would suggest this normally occurs to batters and would not occur during slow pitch softball. The frequency of collisions suggests that recreational softball does not diminish the competitive nature of military personnel. Finally, although running is not in the top three scenarios for softball, it is consistently found in the top three injury-producing sports (that is, basketball, softball, and football) and is, therefore, a worthy target for prevention.

E. IMPLICATIONS FOR PREVENTION.

(1) Although proven prevention equipment (breakaway bases) and rule options (restricting sliding) exist, sliding remains the primary cause (23 percent) of softball injuries. The use of breakaway bases at many USAF bases may explain why the USAF proportion of softball injuries due to sliding is lower than their current civilian counterparts (70 percent)⁽¹⁸⁾ and historical military populations (42-percent U.S. Army,⁽⁴⁾ 45-percent USAF⁽¹¹⁾). However, sliding injuries reported to GSAS have increased 84 percent since 1998. This suggests that—among other possibilities—worn and expensive breakaway bases may frequently be replaced with less expensive stationary bases. Breakaway bases are currently mandated, but this policy may need greater enforcement. These data also suggest that sliding injuries will still occur even with the wide implementation of breakaway bases. Some sliding injuries occur before the runner contacts the base. The soft, uneven dirt found in a batter's box may make separate home plates and rule changes necessary for preventing sliding injuries at home. This countermeasure also has the added benefit of eliminating collisions near home plate.

(2) Two-thirds of the players injured when hit by a ball were hit somewhere on the head. Helmets equipped with face guards should eliminate this injury if worn throughout the game. In contrast to baseball, protection from the ball is most important when not batting. Reduced Injury Factor balls could reduce hit-by-ball injuries of other anatomic sites by reducing the velocity of the ball and the resulting energy of impact.

(3) The emerging popularity of balance training provides one potential prevention tool for injuries in several categories. Finally, the importance of warming up rather than stretching prior

to the game is an idea that is not yet widely recognized and can potentially reduce many leg injuries in this, and every sport, in which running is involved.

(4) Apart from the fact that breakaway bases are mandated in the USAF, softball play in the military should closely compare to play in the civilian sector. Therefore, this study should also provide valuable information for prevention of softball injuries outside the military.

F. KEY POINTS.

(1) Safety data provides mishap detail valuable to forming countermeasures.

(2) Only three mechanisms (that is, sliding, hit by ball, and collision) represent 60 percent of the softball injuries.

(3) Safety data contains information that could be used for the basis of future improvement to external cause coding.

(4) It appears that the widespread use of breakaway bases in the USAF is at least correlated to a lower percentage of sliding injuries.

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4-4. BASKETBALL: MECHANISMS OF INJURY FROM ACCIDENT REPORTS

A. INTRODUCTION.

(1) Historically, the focus of safety has been directed toward preventing fatalities. However, the U.S. Air Force (USAF) has recently taken a more active interest in reducing lost workday injuries. In an effort to better understand the nature of lost workday injuries, an in-depth descriptive epidemiologic study was accomplished at the Air Force Safety Center (AFSC) using data from the Air Force Ground mishap reporting system, the Ground Safety Automated System (GSAS).

(2) Numerous civilian and military studies have shown basketball to be a leading cause of injuries.⁽¹⁻⁶⁾ While strain and sprains of the lower extremity are found to be most common injuries, a wide range of injury types and body parts have been documented.⁽⁷⁻¹²⁾ There are few studies that attempt to address the cause of basketball injuries through identifying risk factors or mechanisms.

(3) These studies are a good start but lack an extensive description of the detailed events that cause basketball injuries. The present study attempts to use GSAS—a large, detailed mishap reporting (safety) database—to fill the gap present in the literature regarding the different mechanisms of injury in adult recreational basketball. The generic external cause codes generated for all injuries are not specific enough for developing interventions for individual sports. Most medical sources of data do not provide either an adequate number of injury reports to allow aggregation into mechanisms or sufficient detail for description. These data should provide a good start toward that effort.

(4) This section focuses on lost workday injuries arising from participation in organized basketball.

B. METHODS.

(1) The terms “hazard scenario” and “mechanism” were considered to be roughly interchangeable and differ mainly in use by area of interest (medicine versus safety). In this section, the term “mechanism” is used. Detailed methods for developing and identifying mechanism are given in a separate paper in paragraph 4-1.⁽¹³⁾ In short, GSAS data from 1993–2002 were analyzed and grouped by activity—this section describes only basketball injuries. The GSAS contains safety reports on the USAF Active Duty population which is young, predominately male, and physically active. Descriptive statistics (that is, frequencies, distributions) were produced for a wide variety of factors, such as fiscal year, age, major command, functional area, injury type, and activity. Within each injury activity, descriptive mechanisms were developed that could potentially inform prevention efforts. Since a list of

mechanisms had not previously been developed in GSAS, the list was formulated using a long process of reading reports, aggregating similar mishaps, and continually refining the list to capture the greatest number of mishaps. The final list of mechanisms (Table 4-4-1) captured 86 percent of the mishaps that occurred during the study period.

TABLE 4-4-1. FREQUENCY OF OBSERVED SCENARIOS PRODUCING BASKETBALL INJURIES, AND POTENTIAL PREVENTION MODALITIES, ACTIVE DUTY U.S. AIR FORCE PERSONNEL, 1993–2002

Mechanism	Example(s)	Injuries Reported (% of Total)	Prevention
Jumped, landed awkwardly, on side of foot	- Jumped for rebound, rolled ankle - After lay-up, landed on side of foot - <i>Excludes:</i> Landed on other player's foot	578 (26%)	- Implement training to improve balance ⁽¹⁴⁾ - Ankle braces ⁽¹⁵⁾
Jumped, landed on player's foot	- Jumped, landed on defender's foot - Came down on foot when rebounding - <i>Excludes:</i> Jumping, did not land on player's foot	370 (17%)	- Implement training to improve balance - Ankle braces
Struck by another player (push, kick)	- Struck by player in eye - Elbowed by player in nose - <i>Excludes:</i> Collision, struck by ball	100 (11%)	- Eye guards, mouth guards
Collision	- Collided with another player - Ran into from behind - <i>Excludes:</i> Undercut, struck by	221(10%)	
Running, pivoting, cutting	- Pivoted quickly and injured foot - Stopped quickly and strained knee - <i>Excludes:</i> Collision, jumping, fall	145 (7%)	- Shift emphasis from stretching to warming up prior to play
Injured Achilles	- Ruptured Achilles tendon - Tore Achilles tendon - <i>Excludes:</i> Other tendons	162 (7%)	- Conditioning; shift emphasis from stretching to warming up prior to play
Fell, unspecified	- Slipped and fell - Fell and landed on wrist - <i>Excludes:</i> Collision, struck by	139 (6%)	- Implement training to improve balance; dry floors
Twisted ankle, unspecified	- Twisted and sprained ankle - Twisted and sprained knee - <i>Excludes:</i> Jumped, landed on foot	44 (2%)	- Implement training to improve balance - Ankle braces

Note: Total basketball-related LWIs reported to the AFSC, 1993-2002 = 2,204.

(2) Gender was not a factor in this study since female participation was extremely limited. Rates can be less accurate for sports than for other activities, such as operating motor vehicles, since denominators are often based on population rather than participation and a much higher percentage operate vehicles than play one particular sport. For a military population, virtually everyone drives, while basketball is routinely played by a much smaller percentage, and no accurate means of estimating players exists. Since the proportion of Active Duty USAF

personnel involved in basketball activities is unknown, only frequencies of mechanisms are presented (rates could not be calculated).

C. RESULTS.

(1) Basketball is the leading producer of injuries in the sports and recreation subcategory during this period and remained so for 2002. With 2,204 total LWIs reported, basketball ranks number four overall, with almost twice the number of injuries of its nearest sports and recreation competitor, softball. For USAF Active Duty personnel during this time period, basketball ranked third overall in total injuries, and fourth in total lost workdays (LWDs) when only military reports are summarized (Table 4-4-2).

TABLE 4-4-2. TOP 10 ACTIVITIES ASSOCIATED WITH LOST WORKDAY INJURIES REPORTED TO THE AIR FORCE SAFETY CENTER, ACTIVE DUTY U.S. AIR FORCE PERSONNEL, 1993–2002^a

Rank	Activity	Total LWDs	Total LWIs	LWDs Per Injury (Mean/Median)	On-Base Percent
1	Operating vehicles/ equipment	46,818	4,390	10.7 / 3	13
2	Basketball	12,520	2,165	5.8 / 2	78
3	Slips, trips, and falls (STF) ^b	14,554	2,032	7.2 / 3	61
4	Lifting/carrying (non-STF)	3,386	1,231	2.8 / 2	72
5	Softball	6,843	1,171	5.8 / 3	71
6	Riding in/on vehicles or equipment	13,023	1,147	11.4 / 4	16
7	Climb/descend stairs or ladder	6,902	965	7.2 / 3	59
8	Flag football	5,406	939	5.8 / 3	74
9	Struck/struck by object ^c	5,208	932	5.6 / 2	73
10	Trail riding—dirt bike/all-terrain vehicle (ATV)/Quad	5,563	454	12.3 / 7	8

Notes:

^a Excludes categories, such as “standing,” which conveys only incidental activities.

^b Numerous activities were associated with this category, but specific well-defined activities (e.g., STFs due to playing basketball or softball or climbing a ladder or stairs) were included in those more specific categories rather than being included under this general STF category. Activity breakdown: general walking (n = 2,363); stepping up or down from/to uneven surfaces such as curbs (n = 380); entering/exiting buildings or vehicles (n = 368); carrying items (n = 254); while handling or carrying items or equipment (n = 155); running—not associated with sports, jogging, or physical training (n = 138); and dozens of other activities.

^c Does not include persons being stuck by objects that they dropped; being struck by a dropped object is categorized here as lift/carry/handle; also does not include being hit by a motor vehicle (pedestrian injuries are included in lower frequency categories not included in this table).

(2) The On-Base Percent column in Table 4-4-2 reflects the percentage of mishaps occurring on a military installation. All three of the major sports (that is, basketball, softball, and football) have roughly three-quarters of the injuries occurring on base—reflecting the high number of recreational facilities per capita on base. Although basketball injuries have decreased in total number for much of the last decade, a plateau was reached in 1998 (Figure 4-4-1). Table 4-4-1 summarizes the 2,204 basketball injuries reported by mechanism. It also gives specific examples of the injuries found in that group, and those excluded from that group. Finally, it describes potential interventions for preventing injuries in that group. Only two specific mechanisms—landing after jumping (such as, landing awkwardly, and landing on someone else’s foot)—represent 43 of the injuries. Though Table 4-4-1 provides more detail, the top five mechanisms (71 percent) could be summarized as jumping, player contact, and running/pivoting/cutting to gather a majority of the injuries.

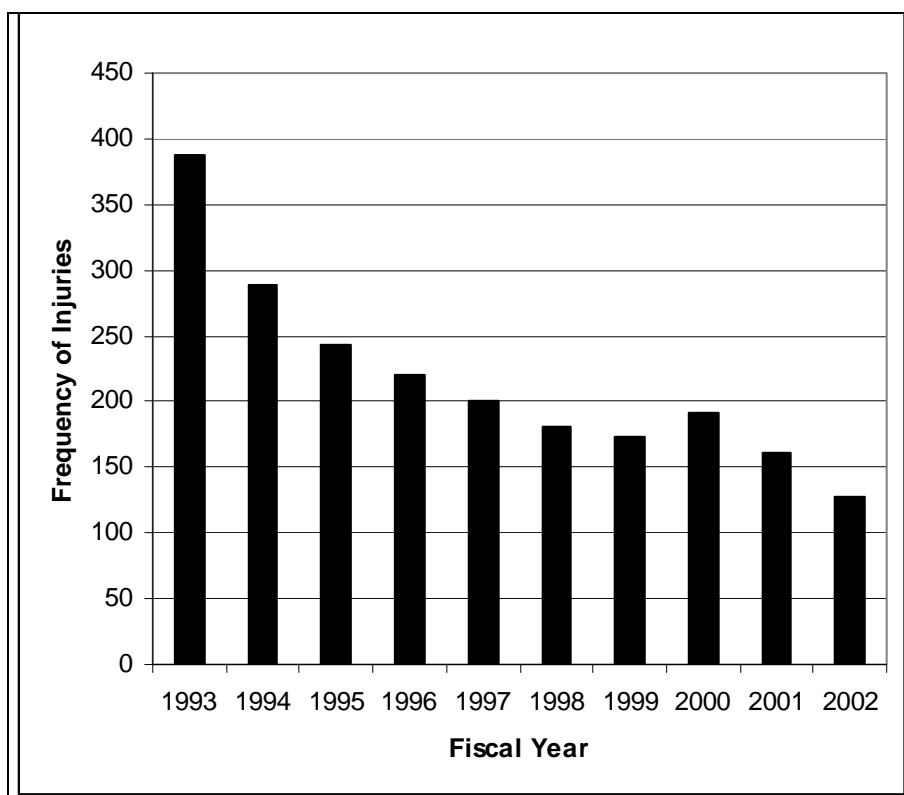


FIGURE 4-4-1. FREQUENCY OF BASKETBALL-RELATED LOST WORKDAY INJURIES REPORTED TO THE AIR FORCE SAFETY CENTER HEADQUARTERS, FY 1993–2002

(3) For important detail, mechanisms were finely separated. However, the top five mechanisms could be summarized as jumping, player contact, and running/pivoting/cutting to gather a majority of the injuries (71 percent).

D. DISCUSSION.

(1) The decreasing trend for basketball injuries during the 1990s should not be over interpreted. Since almost all of the total injuries for other activities have decreased in a similar trend during this period, the decrease is probably due to the drawdown in Active Duty members rather than from the implementation of any countermeasure.

(2) These findings compare closely to other studies regarding mechanisms of basketball injury. One large observational study documented 10,393 participations and 40 injuries. Three risk factors were identified: a history of ankle injury, players wearing shoes with air insoles, and players who did not stretch before the game. This study identified eight mechanisms: landing (45 percent, half on another foot and half on floor), sharp twist or turn (30 percent), collision (10 percent), fall (5 percent), other (5 percent), sudden stopping (2.5 percent), and tripping (2.5 percent).⁽¹⁶⁾ A video analysis of 39 anterior cruciate injuries of basketball players determined female players landed with more knee and hip flexion and had a higher relative risk of sustaining a valgus collapse than male players.⁽¹⁷⁾ A large interview survey that used a classification scheme based on the International Classification of External Causes of Injury system found that the most common mechanisms for all sports and recreation injuries were struck by/against, fall, and overexertion.⁽¹⁸⁾ Hootman's extensive review of 15 National Collegiate Athletic Association sports found that player contact was the most common mechanism for sports overall, and produced the majority of injuries even in sports that limit or restrict player contact, such as basketball.⁽¹⁹⁾

(3) The large percentage of injuries post-jumping also agrees with the current literature⁽²⁰⁻²³⁾ and is particularly noteworthy since they are almost entirely injuries to the ankle and point to the rewards of developing successful countermeasures targeted against that single cause. These injuries also present a unique opportunity for prevention since a higher percentage (78 percent) of these injuries occur on base than any other sports and recreation activity. The USAF could well provide the evidence and impetus needed to fuel a much broader acceptance of successful ankle injury countermeasures.

(4) A number of articles focus on preventing ankle injuries, the most common basketball injury.^(14, 15, 23-31) These studies focus on ankle braces, ankle taping, and balance training.

(5) Ankle taping and balance training were judged to require a significant level of unavailable time and expertise for broad application. Therefore, the AFSC initiated a demonstration project in 2006 to evaluate the acceptability of mandating universal use of semi-rigid ankle braces at two USAF bases. Ankle braces were required for all intramural basketball games for one complete season. The number of players at the USAF bases were insufficient to prove the efficacy of ankle braces; however, the project did show that required use of braces on a community-wide scale was possible. Although the braces were supplied to the players by the

USAF, the project found that a greater selection of braces would increase acceptability (AFSC, unpublished report).

E. KEY POINTS.

- (1) Safety data provides mishap detail valuable to forming countermeasures.
- (2) Only two specific mechanisms—landing after jumping (landing awkwardly, and landing on someone else's foot)—represent 43 percent of the injuries.
- (3) Safety data contains information that could be used as the basis for future improvements to external cause coding.
- (4) The large number of ankle sprains presents a unique opportunity for prevention through the introduction of ankle braces.

F. Acknowledgments. We gratefully acknowledge all the members of the Research and Epidemiology Branch who participated in this project. DJ Atkins, Tom Schultz, and Donna Roper all provided invaluable support in data abstraction and guidance in this project. The work was entirely funded by the HQ Air Force Safety Center.

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4-5. FLAG FOOTBALL: MECHANISMS OF INJURY FROM ACCIDENT REPORTS

A. INTRODUCTION.

(1) The published literature regarding flag football is very limited and some of the best articles are very dated. Kraus and Gullen used 9 years of injuries reported to the University of Minnesota Health Service to investigate predictor variables (risk factors) associated with touch football since it was the largest contributor of intramural athletic injuries.⁽¹⁾ A review of quadriceps contusions in West Point cadets found that tackle football was the leading cause of injury, touch was tied for the third leading cause, and tackle caused 4 times as many injuries as touch.⁽²⁾ Of 90 cases followed in a prospective longitudinal study of anterior cruciate ligament reconstruction, 18 percent were caused by touch football, the fourth leading cause.⁽³⁾ A descriptive study of lost workday injuries occurring on a U.S. Navy aircraft carrier found that basketball, volleyball, and touch football were the top three recreational activities causing injury.⁽⁴⁾

(2) This review was expanded beyond the limited scope of touch football to determine if related information could be found in other types of football. Touch football or “touch” is played extensively in Australia and New Zealand and appears to be a blend of rugby and touch football as played in the United States. In this sport where no tackling is allowed and excessive force is severely penalized, a retrospective survey of 345 players over a 1-year period found that 71 percent of injuries were to the lower limb, less than 3 percent affected the head or neck, and 54 percent were mild.⁽⁵⁾

(3) The review of the literature was also extended to include tackle football since the volume of research is much more extensive and may provide some overlap with touch football. According to the National Electronic Injury Surveillance System (NEISS), sports- and recreation-related injuries comprised 16 percent of all unintentional injury-related emergency department visits in the period July 2000–June 2001. Furthermore, football was among the leading causes of injury in age categories 15–19, 20–24, and 25–44.⁽⁶⁾ A second NEISS for nonfatal traumatic brain injuries in years 2001 to 2005 found that, when all age groups were considered, football was the second leading cause of injury.⁽⁷⁾

(4) The present study is part of a larger descriptive epidemiologic study conducted by the U.S. Air Force Safety Center (AFSC) to focus greater attention on, and reduce the number of LWIs in the U.S. Air Force (USAF). Since identifying the mechanism of injury is central to the development of effective countermeasures, this article attempts to fill the current gap in the literature regarding the mechanism of injuries that occur during participation in flag football.

B. METHODS. The terms “hazard scenario” and “mechanism” were considered to be roughly interchangeable and differ mainly in use by area of interest (medicine versus safety). In this

section, the term “mechanism” is used. Detailed methods for developing and identifying mechanisms are given in Section 4-1.⁽⁸⁾ In short, Ground Safety Automated System (GSAS) data from 1993–2002 were analyzed and grouped by activity. The GSAS contains safety reports on the USAF Active Duty population, which is young, predominately male, and physically active. Descriptive statistics (such as, frequencies, distributions) were produced for a wide variety of factors, such as fiscal year, age, major command, functional area, injury type, and activity. Within each injury activity, descriptive mechanisms were developed that would potentially inform prevention efforts. Since a list of mechanisms had not previously been developed in GSAS, the list was formulated using a long process of reading reports, aggregating similar mishaps, and continually refining the list to capture the greatest number of mishaps. The final list of mechanisms (Table 4-5-1) captured 92 percent of the mishaps that occurred during the study period. Gender was not a factor in this study since female participation was extremely limited. Since almost all of the total injuries for other activities have decreased in a similar trend during this period, the decrease is probably due to the drawdown in Active Duty members rather than from the implementation of any countermeasure. However, this decrease in frequency should not be over interpreted. Since exposure cannot be determined (an unknown, relatively small proportion play flag football), calculating rates were determined to be of little value; only frequencies of mechanisms are presented. Data are only presented for Active Duty military.

TABLE 4-5-1. FREQUENCY OF OBSERVED SCENARIOS PRODUCING FOOTBALL INJURIES AND THEIR PROPORTIONATE CONTRIBUTION TO THE FIELD OF FOOTBALL-RELATED INJURIES, WITH POTENTIAL PREVENTION MODALITIES

Mechanism	Example(s)	Injuries Reported (%)	Prevention
Contact with another player	- Tackled, fractured ankle - Kicked in ankle by player	393 (42%)	- Implement and enforce rules to minimize contact (i.e., no tackling)
Slips, trips, and falls (STFs)	- Fell while running - Excludes: Tripping over player or object, bad field, ball	129 (14%)	- Training to improve balance
Running	- Heard pop while running - Knee gave out while running - Excludes: Collision while running	100 (11%)	- Shift emphasis from stretching to warming up prior to play - Preseason conditioning
Plant foot, cut, change direction	- Knee popped while changing directions - Cut sharply to catch ball - Excludes: Running, unspecified	66 (7%)	- Brace previously injured or weak knees and ankles - Wear shortened cleats
Jumped (leg injury)	- Jumped to deflect a pass - Jumped to catch a ball - Excludes: Hit by ball	57 (6%)	- Training to improve balance

TABLE 4-5-1. FREQUENCY OF OBSERVED SCENARIOS PRODUCING FOOTBALL INJURIES AND THEIR PROPORTIONATE CONTRIBUTION TO THE FIELD OF FOOTBALL-RELATED INJURIES, WITH POTENTIAL PREVENTION MODALITIES (CONTINUED)

Mechanism	Example(s)	Injuries Reported (%)	Prevention
Grabbing the flag	- Jammed thumb while grabbing flag - Caught finger on pocket	43 (5%)	- Enforce no pocket rule - Improve flag system
Uneven surface, hole, mud	- Stepped in a hole while running - Tripped on a dirt pile - Excludes: Fall, unspecified	36 (4%)	- Improve playing field - Cancel/postpone game if field is too sloppy
Stepped on ball, hit by ball	- Stepped on ball, sprained ankle - Hand hit by passed ball	26 (3%)	

Note: Total flag football-related LWIs reported to the AFSC, 1993–2002 = 944.

C. RESULTS.

(1) Four of the top 10 activities associated with lost workdays (LWDs) were sports and recreation activities (Table 4-5-2). With 944 total LWIs reported, flag football is the third leading producer of injuries in the sports and recreation category, behind basketball and softball. As an activity, it ranks ninth in overall production of LWIs and tenth overall in total LWDs. However, it climbs to eighth overall in both total injuries and total LWDs when only military reports are summarized (Table 4-5-2).

TABLE 4-5-2. TOP 10 ACTIVITIES ASSOCIATED WITH LOST WORKDAY INJURIES REPORTED TO THE U.S. AIR FORCE SAFETY CENTER, ACTIVE DUTY AIR FORCE PERSONNEL, 1993–2002^a

Rank	Activity	Total LWIs	Total LWDs	LWDs Per Injury (Mean/Median)	On-Base Percent
1	Operating vehicles/equipment	4,390	46,818	10.7 / 3	13
2	Basketball	2,165	12,520	5.8 / 2	78
3	Slips, falls, and trips (STF) ^b	2,032	14,554	7.2 / 3	61
4	Lifting/carrying (non-STF)	1,231	3,386	2.8 / 2	72
5	Softball	1,171	6,843	5.8 / 3	71
6	Riding in/on vehicles or equipment	1,147	13,023	11.4 / 4	16
7	Climb/descend stairs or ladder	965	6,902	7.2 / 3	59
8	Flag football	944	5,406	5.8 / 3	74

TABLE 4-5-2. TOP 10 ACTIVITIES ASSOCIATED WITH LOST WORKDAY INJURIES REPORTED TO THE U.S. AIR FORCE SAFETY CENTER, ACTIVE DUTY AIR FORCE PERSONNEL, 1993-2002^a (CONTINUED)

Rank	Activity	Total LWIs	Total LWDs	LWDs Per Injury (Mean/Median)	On-Base Percent
9	Struck/struck by object ^c	932	5,208	5.6 / 2	73
10	Trail riding—dirt bike/all-terrain vehicle/Quad	454	5,563	12.3 / 7	8

Notes:

^a Excludes categories, such as “standing,” which conveys only incidental activities.

^b Numerous activities were associated with this category but specific well-defined activities (e.g., STFs due to playing basketball or softball or climbing a ladder or stairs) were included in those more specific categories rather than being included under this general STF category). Activity breakdown: general walking (n = 2,363); stepping up or down from/to uneven surfaces such as curbs (n = 380); entering/exiting buildings or vehicles (n = 368); carrying items (n = 254); while handling or carrying items or equipment (n = 155); running—not associated with sports, jogging, or physical training (n = 138); and dozens of other activities.

^c Does not include persons being struck by objects that they dropped; being struck by a dropped object is categorized here as lift/carry/handle; also does not include being hit by a motor vehicle (pedestrian injuries are included in lower frequency categories not included in this table).

(2) The On-Base Percent column in Table 4-5-2 reflects the percentage of mishaps occurring on a military installation. Table 4-5-1 summarizes the 944 flag football injuries reported by mechanism. The aggregation methodology was able to group 92 percent of the injuries into the eight mechanisms developed for flag football. It also gives specific examples of the injuries found in that group and those excluded from that group. Finally, it describes potential interventions for preventing injuries in that group. Despite the fact that flag football is intended to reduce contact and, therefore, promote safety, the leading mechanism was contact with another player; this caused a full 42 percent of the reported injuries, 3 times that of the second leading scenario, STFs associated with flag football play (14 percent). Running during flag football play was the third leading mechanism identified (11 percent). The remainder of the injuries was more evenly distributed among the five other scenarios.

(3) Since exposure cannot be determined (an unknown, relatively small proportion play flag football), calculating rates were determined to be of little value.

D. DISCUSSION.

(1) As modern populations grow obese, encouraging physically demanding activities becomes increasingly important. However, with increased participation comes increased risk of injury. Furthermore, participants are both educated and independent and, therefore, will only tolerate activity constraints which are proven to be effective. Detailed surveillance of these sports-related activities becomes increasingly important to provide data-driven, effective countermeasures that minimize the impact on the activity itself. Examples of prior data-driven changes in civilian sports policies include educational efforts to reduce heat-related football

injuries, elimination of racing starts in the shallow end of pools, and eye protection in sports involving sticks.⁽⁹⁾ Physical activity for military members is not only important, but required specifically to meet aerobic, callisthenic, and mandatory weight requirements. Furthermore, while injury is important to all employers and employees, it has a direct impact on military readiness. At the present time, injury plays an even more important role due to its impact on deployed forces that are already stretched thin.

(2) Studies that provide a description of the magnitude of the injury problem, body part, and type of injury are not uncommon. However, medical databases do not often describe the injury details relating to the mechanism, a critical drawback to developing effective countermeasures. Therefore, short-term, expensive prospective studies are accomplished to overcome this deficit. The USAF overcomes this problem by using trained investigators who report the details of each mishap into a mishap reporting system. This luxury, which is rarely available outside of large corporations, is justified by its potential to reduce injury's impact on force readiness.

(3) The finding by Dick et al.,⁽¹⁰⁾ that overall injury rates have had little variation over a recent 16-year period is disheartening to injury prevention researchers and advocates. He suggests that improvements in strength and conditioning programs that should have decreased rates have been offset by the same factors increasing speed and collision forces, which also cause more injuries.

(4) One review of many years of the National Collegiate Athletic Association's Annual Survey of Football Injury Research⁽¹¹⁾ listed findings regarding catastrophic injuries in tackle football. The vast majority of these injuries were caused either by "head-down" blocking and tackling or heat-related injuries. Flag or touch football should not cause these same injuries since helmets are not used, tackling is rare, and the large amount of protective equipment that decreases ventilation is not used. One encouraging note was the reduction in catastrophic cervical spine injuries following the prohibition of spear tackling.

(5) Although flag football injury reports decreased in total number in the first half of the 1990s, the trend slowed, thereafter, and has reached a plateau (Figure 4-5-1). However, this decrease in frequency should not be over interpreted. Since almost all of the total injuries for other activities have decreased in a similar trend during this period, the decrease is probably due to the drawdown in Active Duty members rather than from the implementation of any countermeasure.

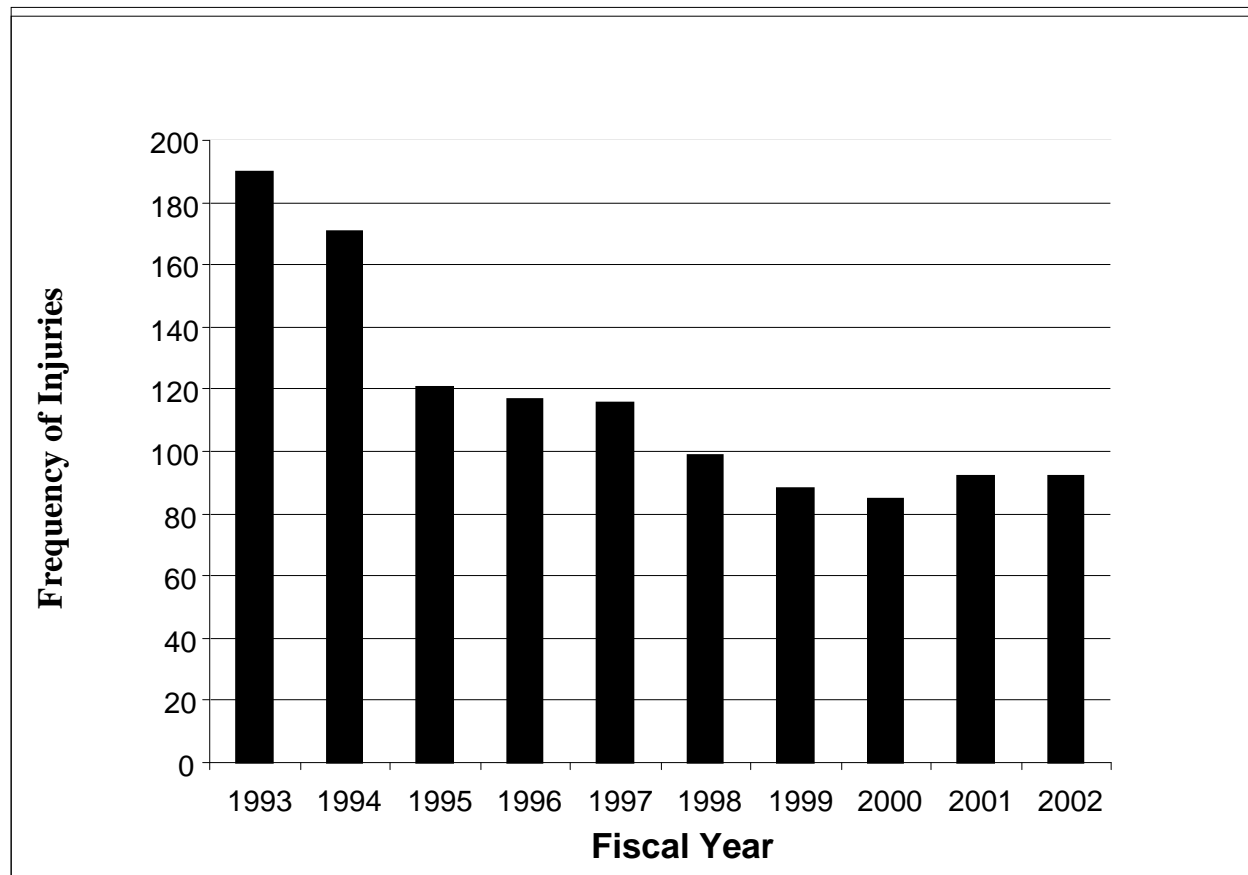


FIGURE 4-5-1. FREQUENCY OF FLAG FOOTBALL-RELATED LOST WORKDAY INJURIES AS REPORTED TO THE AIR FORCE SAFETY CENTER HEADQUARTERS, FY 1993–2002

(6) The large percentage of football injuries that occur on base (74 percent, Table 4-5-2) is an important factor since the circumstances surrounding those mishaps are under military control and allow countermeasures to be implemented without approval by outside agencies.

(7) A recent summary of 16 years of collegiate football injuries may be particularly appropriate since it describes injuries to an age group more similar to that of the military.⁽¹²⁾ It found football to have the highest injury rate of 15 sports and to cause the highest number of concussions. Importantly, Hootman loosely described mechanism of injury and found the majority of all sports injuries to be caused by player contact.⁽¹²⁾ A similar effort focusing on football injuries also found that player contact caused 59 percent of all injuries.⁽¹¹⁾ These findings suggest that touch football (or “touch” as suggested by Neumann⁽⁵⁾) should produce far fewer injuries than tackle football. Disappointingly, this study also found little variation of injury over time, suggesting that prevention efforts have not been implemented or have had little impact. The most important finding of the present study is that, contrary to the expectations

mentioned in the introduction, player contact still produces the majority of injuries in flag football. However, this problem may turn into an advantage since this concentration of injuries provides a worthy target for countermeasure implementation. The initiation of new rules and enforcement of current rules may provide the easiest path to address this issue. The remainder of injuries was evenly distributed among the other scenarios, which makes the targeting of interventions more difficult.

E. KEY POINTS.

- (1) Safety data provides mishap detail valuable to forming countermeasures.
- (2) Safety data contains information that could be used as a basis for future improvements to external cause coding.
- (3) Despite the fact that flag football is intended to provide a safer alternative to tackle football, 42 percent of injuries are due to contact.
- (4) It appears that the high percentage of contact injuries represents an opportunity for prevention through rule changes and increased enforcement.

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CHAPTER 5

REVIEWS OF THE SCIENTIFIC EVIDENCE TO IDENTIFY OPPORTUNITIES FOR PREVENTION

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5-1. RECOMMENDATIONS FOR PREVENTION OF PHYSICAL TRAINING-RELATED INJURIES:
SUMMARY OF A SYSTEMATIC EVIDENCE-BASED REVIEW

A. BACKGROUND.

(1) Injuries represent the leading health problem of U.S. military personnel across the spectrum of health from deaths and disabilities to hospitalization and outpatient care. Training-related injuries have been identified as the leading cause of clinic visits, and they have a substantial impact on the readiness of the Force due to the amount of limited duty time they cause. Most of the injuries sustained in a military environment are due to weight-bearing physical training activities such as running, particularly for basic military trainees. Additionally, physical training is responsible for a number of preventable acute or traumatic injuries.

(2) The Military Training Task Force (MTTF) of the Defense Safety Oversight Council was formed to support the Secretary of Defense's accident and injury prevention mandate, with a focus on interventions that relate to all aspects of military training. The Joint Services Physical Training Injury Prevention Work Group (JSPTIPWG) was chartered under the MTTF in September 2004 to evaluate military physical training injury prevention programs, policies, and research and provide cross-Service recommendations to reduce physical training-related injuries during and after initial entry training.

B. METHODS.

(1) The Chair of the Military Training Task Force invited military and civilian experts to serve on the JSPTIPWG. The final group of 29 researchers, public health practitioners, clinicians, training officers, epidemiologists, and analysts represented the four Services and included experts from the Centers for Disease Control and Prevention and professors at academic institutions. See Appendix A for a listing of JSPTIPWG Members.

(2) Co-chairs for the work group (WG) established the systematic literature search and review process, developed inclusion and exclusion criteria for studies identified in the search process, and delegated responsibility for each of the intervention topics to be searched.

(3) An initial list of topics was derived from previous panel discussions and recommendations. Brainstorming sessions held by the JSPTIPWG expanded this list. Each topic on the expanded list was assigned to groups of several JSPTIPWG members who conducted literature searches and rated studies related to each intervention. The literature review process was outlined in five steps that were to be completed before the face-to-face meeting. Prior to this meeting, individual Work Group (WG) members: (1) conducted an online literature search for the specific intervention topics, (2) created reference lists of the studies that met the inclusion criteria, (3) scored the quality of each intervention and risk factor study, (4) classified literature by study type and assessed the strength of the evidence for intervention topics, and (5)

concluded with a final recommendation using a format adapted from the U.S. Preventive Services Task Force (USPSTF).

(4) All intervention strategies that were considered to have sufficient scientific evidence by the reviewers were discussed by all members of the WG. Each WG member had an opportunity to see and comment on the quality scores from each review. Factors that weighed in on the discussion included: (1) the number of intervention studies demonstrating effectiveness (randomized controlled trials, observational studies, or systematic reviews); (2) the consistency of the evidence (the number of studies showing efficacy versus no efficacy or harm); (3) the quality of the evidence (scores ≤ 3 = low quality, 4-6 = average quality, ≥ 7 = high quality); and (4) the number of other interventions included in each study (multiple versus single). After discussing all of the intervention topics on which literature searches had been completed, the JSPTIPWG decided that to be considered effective, strategies had to be shown to reduce injury rates by more than one or two prospective, randomized (or observational) studies; the results had to consistently show a reduction across multiple studies; and the quality of at least some of the studies had to be high. Intervention strategies with these characteristics were considered to have sufficient strength of scientific evidence to make Quad-Service recommendations. However, in the absence of injury outcomes—if there was an overwhelming reduction of validated markers for injury—in a rare instance (such as, nutrient replenishment intervention), it was accepted as having sufficient evidence. The WG agreed that the best criterion for objectively ranking the priority for implementing strategies was an adaptation of the USPSTF guidelines. Injury prevention strategies were subsequently categorized as follows:

- (A) Essential Elements of an Injury Prevention Program (not interventions).
- (B) Recommended Interventions (based on sufficient scientific evidence).
- (C) Interventions Not Recommended (due to evidence of ineffectiveness or harm).
- (D) Interventions without Sufficient Evidence to Recommend at this Time.
- (E) Interventions without a Completed Review (interventions that require a systematic literature review, WG discussion, and objective assessment).

(5) The recommended interventions were then prioritized using a refined set of criteria initially developed through a joint effort between the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) and the Johns Hopkins Center for Injury Research and Policy (JHCIRP). The USACHPPM-JHCIRP criteria provided a systematic means of objectively rating and ranking injury prevention interventions to arrive at a prioritized list of recommended interventions to reduce military physical training-related injuries.

(6) Overall, the process used by the JSPTIPWG served three primary purposes—

(A) To establish the evidence base for making recommendations to prevent injuries.

(B) To prioritize the recommendations for prevention programs and policies.

(C) To substantiate the need for further research and evaluation on interventions and programs likely to reduce physical training-related injuries.

(7) Details of this process, results (including reference lists), and conclusions of the JSPTIPWG are documented in a USACHPPM Technical Report.⁽¹⁾ A summary of the JSPTIPWG's findings and recommendations follow.

C. RESULTS AND DISCUSSION.

(1) The JSPTIPWG identified essential elements of a successful injury prevention program (education, enforcement of policies, surveillance, and research) and interventions needing systematic review. The initial list of injury prevention strategies was derived from previous panel discussions and recommendations consisted of 27 interventions. Following JSPTIPWG brainstorming sessions, this list was expanded to 49 strategies with potential to reduce the incidence of physical training-related injuries. Subsequently, when similarities between the interventions were identified, selected topics were combined, resulting in 40 interventions. Of the 40 remaining physical training-related injury prevention strategies reviewed by the JSPTIPWG, three were determined to be critical components of a successful injury prevention program and not interventions in and of themselves. Therefore, rather than addressing these components as independent injury prevention interventions, the WG agreed to categorize them as essential elements of a successful injury prevention program that are interdependent with proven prevention strategies. Because of lack of scientific evidence for most of the interventions identified, the WG deemed it prudent to add one more “essential element”—greater investment of resources in research and program evaluation—to the list, bringing the list of essential elements to 4 and the total intervention strategies considered to 37.

(2) By the time the face-to-face meeting convened, intervention studies were identified and reviewed for 23 (62 percent) of the 37 strategies. In the months that followed the 3-day face-to-face meeting, JSPTIPWG members updated their original reviews and conducted further literature reviews to identify published research related to 31 of the 37 original strategies and discussed them by electronic mail and telephone. These and other studies considered for further review included research studies with injury and noninjury outcome(s) and systematic reviews of injury research. The 31 interventions were then categorized into three levels representing the strength of recommendation: (1) recommended, (2) not recommended, and (3) insufficient evidence to recommend or not recommend. In some cases where reviews were not completed,

the WG chair performed an expedited review in order to make comment about the rationale behind future consideration of the intervention strategy.

(3) Recommendations related to each of the essential program elements and 37 injury prevention strategies are summarized below in the 5 categories described earlier.

(A) ESSENTIAL ELEMENTS OF AN INJURY PREVENTION PROGRAM (NOT INTERVENTIONS).

TABLE 5-1-1. ESSENTIAL ELEMENTS OF AN INJURY PREVENTION PROGRAM

1	Educate military Service members, Especially Leaders, on Injury Prevention Principles and Evidence-based Strategies ⁽²⁻⁴⁾
2	Leadership Enforcement of Injury Prevention Policies and Programs
3	Unit Injury Surveillance Reports
4	Invest Greater Resources in Research and Program Evaluation of Training-Related Injury Prevention Interventions

i. EDUCATE MILITARY SERVICE MEMBERS, ESPECIALLY LEADERS, ON INJURY PREVENTION PRINCIPLES AND EVIDENCE-BASED STRATEGIES (*ESSENTIAL PROGRAM ELEMENT*). The JSPTIPWG recommends injury prevention education for military personnel, including all levels of military leadership as a part of institutionalized continuing military education and distance learning programs. The WG considers education an essential injury prevention program element when these education programs reference and advocate proven (evidence-based) prevention strategies. The reduction of injuries is most likely to occur if all levels of leadership (command and cadre) understand the injury risk factors Service members face and which strategies are effective in preventing them. Education is the first step in identifying and disseminating evidence-based interventions that can be implemented at the unit level and is an essential component of any successful injury reduction program. Through education, leadership can be empowered with the knowledge and skills necessary to effectively reduce injuries in their sphere of influence.

ii. LEADERSHIP ENFORCEMENT OF INJURY PREVENTION POLICIES AND PROGRAMS (*ESSENTIAL PROGRAM ELEMENT*). The JSPTIPWG recommends military and civilian leadership enforcement of injury prevention policies and programs at all levels, including the accountability down to the unit, for injury rates and fitness test pass rates. The WG considers leadership enforcement an essential injury prevention program element. The unit commander is the critical agent for injury prevention intervention and the success of any program is directly related to the level of visible command support and involvement. Effective command emphasis on injury prevention includes accountability and must be consistent, lasting, and based on evidence-based strategies and common sense to reduce exposure to injury risk during combat, physical training, and field training exercises. These same principles can also apply to off-duty recreational and leisure activities.

iii. UNIT INJURY SURVEILLANCE REPORTING (*ESSENTIAL PROGRAM ELEMENT*). The JSPTIPWG recommends unit level and centralized surveillance and reporting. Injury

surveillance is critical for at least three reasons: (1) data on injury outcomes and physical fitness facilitates the prioritization of resources and research, and the targeting of interventions to reduce injury rates as a matter of force health protection; (2) without surveillance of injuries, there is no way to know whether prevention efforts are effective; and (3) surveillance of physical fitness (scores and pass rates) ensure that physical fitness is not adversely affected by injury prevention efforts. The WG considers both unit and centralized surveillance an essential injury prevention program element. The WG encourages units to conduct their own injury and fitness surveillance through simple tools (such as, spreadsheets). Additionally, the WG supports efforts to centralize injury surveillance through mandatory injury-cause coding of acute and overuse injuries in the military outpatient electronic health record (that is, Armed Forces Health Longitudinal Technology Application (AHLTA)) and follow-up reporting of such to unit leaders.

iv. INVEST GREATER RESOURCES IN RESEARCH AND PROGRAM EVALUATION OF TRAINING-RELATED INJURY PREVENTION INTERVENTIONS (ESSENTIAL PROGRAM ELEMENT). The JSPTIPWG recommends a greater investment of resources (Department of Defense (DOD)-wide) in the evaluation of intervention strategies to reduce injuries, the leading health problem impacting U.S. military force readiness. Preventing injuries will have a significant effect on military operational readiness by decreasing entry-level attrition and separations due to injury. The JSPTIPWG found very few interventions with sufficient scientific evidence to evaluate effectiveness. This underscores the need for more research and program evaluation of interventions to prevent musculoskeletal injuries.

(B) RECOMMENDED INTERVENTIONS (BASED ON SUFFICIENT SCIENTIFIC EVIDENCE).

TABLE 5-1-2. RECOMMENDED INTERVENTIONS TO PREVENT PHYSICAL TRAINING-RELATED INJURIES

1	Prevent Overtraining ^(2, 5-14)
2	Perform Multiaxial, Neuromuscular, Proprioceptive, and Agility Training ⁽¹⁵⁻³⁴⁾
3	Wear Mouthguards During High Risk Activities ⁽³⁵⁾
4	Wear Semi-Rigid Ankle Braces for High Risk Activities ^(18, 36-39)
5	Consume Nutrients to Restore Energy Balance within One Hour Following High Intensity Activity ⁽⁴⁰⁻⁴⁵⁾
6	Wear Synthetic Blend Socks to Prevent Blisters ⁽⁴⁶⁻⁴⁸⁾

i. PREVENT OVERTRAINING (STRONGLY RECOMMENDED). The JSPTIPWG recommends a standardized physical training program that controls the amount of total body overload performed, particularly for the lower extremities. Lower-extremity overtraining (caused largely by excessive distance running) results in higher injury rates, lowered physical performance, decreased motivation, and increased attrition. Good evidence was found that physical training programs that reduce distance running miles, especially in initial military training, prevent overtraining and reduce injury rates while maintaining or improving physical fitness. The following elements should be incorporated to assist in reducing running mileage:

- Commanders at all levels should actively avoid combinations of physical and military training that exceed physiologic thresholds of training. Exceeding these thresholds result in higher injury rates with minimal or no improvement in fitness.
- Commanders can monitor profile (limited duty excusals) rates and fitness test-pass rates as well as run times to determine if their units are overtraining. Signs that a unit is overtraining include high or increasing lower body injury profile rates, decreased fitness test pass rates, and slower average run times. See Table 5-1-3 for other ways to achieve this objective.

TABLE 5-1-3. RECOMMENDATIONS FOR PREVENTING OVERTRAINING

<p>Follow a gradual, systematic progression of running distance and speed beginning with lower mileage and intensity, especially for those just starting a physical training program (such as, new recruits, changing units, or returning to physical training after time off for an injury or leave). This practice provides for less total running over a finite period of time.</p>
<p>Structure physical training injury prevention programs to target those Service members at the highest risk of injury (those of average or below average fitness) by ensuring that the running mileage for the least fit Service members is appropriate for their fitness level—</p> <ul style="list-style-type: none"> • Group Service members according to physical ability. For example, fitness test performance (run times) can be used to place Service members in groups of their peers with similar fitness levels. This provides each Service member with a more appropriate level of physiological stimulus to enhance fitness and minimize injury risk. • Run for specified time periods, not distance. This allows the least fit to run shorter distances than the most fit, thus, accommodating low and high fitness groups simultaneously. • Limit running in formation. Placing limits on unit formation running allows a greater chance that Service members are provided an adequate training effect for maximum improvement through ability group running. • Avoid the practice of giving extra physical training sessions to the least fit Service members, especially recruits, since this will increase the risk of overtraining and injury with little or no fitness improvement. (Gradual, progressive ability group training programs improve fitness with less risk of overtraining and injury.) • Refrain from or modify use of physical training as a punitive, corrective, or motivational tool as it has the potential to cause excessive training overload that can lead to overtraining. Other methods to discipline new recruits should be sought or the amount and type of physical demands placed on a new recruit should be limited and standardized (such as, a maximum number of push-ups allowed per day). An activity that Service members should embrace for a career and a lifetime should not be used for punishment.

TABLE 5-1-3. RECOMMENDATIONS FOR PREVENTING OVERTRAINING (CONTINUED)

<p>Replace some distance runs with interval running (multiple bouts of short distance, high-intensity running interspersed with periods of recovery) that increase speed and stamina more rapidly than distance running while limiting total running miles.</p>
<p>Balance the body's need for a physiologic training overload to improve fitness with the need for recovery and rebuilding by coordinating military and physical training to—</p> <ul style="list-style-type: none"> • Avoid exhaustive military or physical training (e.g., obstacle courses, long road marches with heavy loads, longer runs, maximal-effort physical fitness testing, etc.) on the same or successive days. • Allow adequate recovery time between administrations of maximal effort physical fitness tests to prevent overtraining and increase the likelihood of improved physical performance. (Since muscle soreness peaks at 48 hours, the minimum recovery time is 3-5 days). • Alternate training days that emphasize lower body weight-bearing physical activity with training days focused on upper body conditioning. • Minimize the accumulated weight-bearing stress on the lower body from marching/hiking, movements to training sites, drill and ceremony, obstacle courses, running, etc., by not over scheduling such activities on the same or successive days.

ii. PERFORM MULTIAXIAL, NEUROMUSCULAR, PROPRIOCEPTIVE, AND AGILITY TRAINING (RECOMMENDED). The JSPTIPWG recommends that multiaxial (many planes of motion), neuromuscular (coordinated muscular movement), proprioceptive (body position sense), and agility (non-linear movement) exercises be included as a regular component of military physical training programs. The WG found good evidence that injuries are reduced by increasing the proportion of physical training time devoted to exercises that vary musculoskeletal stress in multiple planes and improve body coordination, position sense, and agility.

iii. WEAR MOUTHGUARDS DURING HIGH-RISK ACTIVITIES (RECOMMENDED). The JSPTIPWG recommends all Services provide mouth guards for all Service members participating in activities with a high risk for orofacial injuries. The WG found good evidence that mouth guards reduce orofacial injuries when worn during activities with high orofacial injury risk. Examples of potential high-risk activities listed by the WG include combatives, obstacle and confidence courses, rifle/bayonet training, and so forth, as well as contact sports such as basketball and football. The evidence is insufficient to recommend for or against mouth guards as a means of preventing concussion injuries.

iv. WEAR SEMI-RIGID ANKLE BRACES FOR HIGH-RISK ACTIVITIES (RECOMMENDED). The JSPTIPWG strongly recommends that semi-rigid ankle braces be utilized during participation in high-risk physical activity. The WG found good evidence that semi-rigid ankle braces reduce ankle injuries when participating in high-risk physical activity such as airborne operations

(parachuting), basketball, and soccer; and may prevent ankle injuries in other similar high-risk activities. Additionally, the WG found good evidence that semi-rigid ankle braces reduce re-injury among individuals with previous moderate or severe ankle sprains.

v. CONSUME NUTRIENTS TO RESTORE ENERGY BALANCE WITHIN ONE HOUR FOLLOWING HIGH-INTENSITY ACTIVITY (*RECOMMENDED*). The JSPTIPWG recommends consuming 12–18 grams of protein, 50–75 grams of carbohydrate, and a fluid replacement beverage within 1 hour after very strenuous, continuous physical activity (such as, road marching/hiking lasting longer than 1 hour) to minimize muscle damage and optimize recovery. The WG found sufficient evidence that consuming this balance of nutrients within a 1-hour time frame restores energy balance and optimizes recovery from musculoskeletal breakdown caused by the activity. Collateral benefits such as reduced risk of heat-related illness and enhanced physical performance can be expected.

vi. WEAR SYNTHETIC BLEND SOCKS TO PREVENT BLISTERS (*RECOMMENDED*). The JSPTIPWG recommends the use of synthetic blend socks (such as, polyester, acrylic, and nylon versus cotton socks) to prevent blisters to the feet during physical training. The WG found at least fair evidence that synthetic blend socks prevent blisters to the feet, especially during long distance marching.

(C) INTERVENTIONS NOT RECOMMENDED (DUE TO EVIDENCE OF INEFFECTIVENESS OR HARM).

TABLE 5-1-4. INTERVENTIONS NOT RECOMMENDED TO PREVENT PHYSICAL TRAINING-RELATED INJURIES

1	Wear Back Braces, Harnesses, or Support Belts ⁽⁴⁹⁻⁵⁵⁾
2	Take Anti-Inflammatory Medication Prior to Exercise ⁽⁵⁶⁻⁶¹⁾

i. WEAR BACK BRACES, HARNESSES, OR SUPPORT BELTS (*NOT RECOMMENDED*). The JSPTIPWG does not recommend the use of back braces, harnesses, or support belts for the prevention of low back injuries. The WG found at least moderate to strong evidence that back belts/supports are ineffective or that the potential harms outweigh the benefits. These findings support the Department of Defense (DOD) position that back support belts are not personal protective equipment, and use of these devices for the prevention of back injuries is not endorsed (see DOD Instruction 6055.1, DOD Safety and Occupational Health (SOH) Program, para E6.1.3, August 19, 1998).

ii. TAKE ANTI-INFLAMMATORY MEDICATION PRIOR TO EXERCISE (*NOT RECOMMENDED*). The JSPTIPWG does not recommend taking anti-inflammatory medication prior to exercise for the prevention of injuries. The WG found insufficient evidence for the efficacy of pre-

administration of anti-inflammatory medication for the prevention of injuries. The potential harms outweigh any potential benefits.

(D) INTERVENTIONS WITHOUT SUFFICIENT EVIDENCE TO RECOMMEND AT THIS TIME.

TABLE 5-1-5. INTERVENTIONS WITHOUT SUFFICIENT EVIDENCE TO RECOMMEND FOR PHYSICAL TRAINING-RELATED INJURY PREVENTION

1	Stretch Muscles Before or After Exercise ^(7, 17, 62-80)
2	Reinitiate Exercise at Lower Intensity Levels for Detrained Individuals [†]
3	Target Specific Muscles to Strengthen ^(32, 81, 82)
4	Replace Running Shoes at Standard Intervals ^(17, 83, 84)
5	Warm-up and Cool-down Before and After Activity ⁽⁸⁵⁾
6	Place Shorter Service members in Front of Formations to Set Running Pace and Cadence ⁽⁸⁶⁻⁸⁸⁾
7	Manipulate Stride Length ⁽⁸⁹⁻⁹¹⁾
8	Participate In A Standardized, Graduated Marching (aka Hiking) Program [†]
9	Gradually Increase Load-Bearing During Marching ⁽⁹²⁻⁹⁵⁾
10	Avoid Hazardous Exercises or Exercise Machines [†]
11	Separate Body Weight Assessment and Maximal Effort Physical Fitness Tests
12	Wear Shock-Absorbing Insoles ^(10, 17, 96)
13	Wear Running Shoes Based on Individual Foot Shape ^(17, 84, 97)
14	Wrap Ankle with Athletic Tape Prior to High Risk Activity ^(18, 36, 98-101)
15	Run on Improved Surfaces that Minimize Injury Risk ^(17, 102, 103)
16	Improve Obstacle Course Landing Surfaces ⁽¹⁰⁴⁻¹⁰⁵⁾
17	Adjust Training Loads by Seasonal Variations ⁽¹⁰⁶⁻¹⁰⁸⁾
18	Encourage Smoking Cessation Programs to Prevent Musculoskeletal Injuries ⁽¹⁰⁹⁻¹¹⁴⁾
19	Educate Service members on Safe Lifting Techniques ^(52, 115-122)
20	Apply Ice to Injuries Early to Prevent Re-injury ⁽¹²³⁻¹³¹⁾
21	Take Oral Contraceptives to Decrease Injury ^(27, 132-137)
22	Standardize Unit Reconditioning Program After Rehabilitation ⁽¹³⁸⁻¹⁴⁰⁾
23	Predict Injury Risk through Use of an Injury Risk Index ^(2, 94, 141-144)

Note:

[†] No related reviews, intervention studies, or risk factor studies were found.

i. STRETCH MUSCLES BEFORE OR AFTER EXERCISE (INSUFFICIENT EVIDENCE TO SUPPORT).

THE JSPTIPWG cannot recommend organized stretching as a means for preventing physical training-related injuries. The WG found good evidence that stretching is ineffective as an injury prevention strategy in a generally young, healthy population. Additionally, there is insufficient evidence that it may cause harm. Therefore, while the WG cannot endorse stretching, it also cannot recommend discontinuing stretching before or after exercise in those who perceive a benefit. Studies to date have not specifically targeted individuals with limited range of motion. Because epidemiological data suggest that both extremes of flexibility (too much or too little) are risk factors associated with increased injury rates, the WG recommends research selectively targeting individuals with limited range of motion to determine the effect of stretching in this select population.

ii. REINITIATE EXERCISE AT LOWER INTENSITY LEVELS FOR DETRAINED INDIVIDUALS (*INSUFFICIENT EVIDENCE TO SUPPORT*). The evidence is insufficient to recommend for or against reinitiating exercise at lower levels for the detrained. When individuals stop training due to injury, illness, vacation, or other reasons, they gradually become detrained or lose a portion of their fitness gains. Therefore, it would seem prudent to reinitiate activity at lower than previous levels (see overtraining recommendation). However, there is insufficient evidence to determine how many days of detraining require reinitiating exercise at lower levels. The JSPTIPWG recommends further research into how much detraining requires a lower level of intensity and duration of exercise to prevent injury.

iii. TARGET SPECIFIC MUSCLES TO STRENGTHEN (*INSUFFICIENT EVIDENCE TO SUPPORT*). The evidence is insufficient to recommend for or against targeted muscle strength training and job- or sport-specific strength training for the prevention of injuries. Scientific evaluation of targeted muscle strength training is lacking, of poor quality, or conflicting and the balance of benefits and harms cannot be determined. The WG concludes that more research or program evaluation on the precise series or combinations of strengthening exercises for military training should be conducted.

iv. REPLACE RUNNING SHOES AT STANDARD INTERVALS (*INSUFFICIENT EVIDENCE TO SUPPORT*). Shoe manufacturers and biomechanical studies on running shoes report that shoes should last between 400 and 600 miles and should, therefore, be replaced by that period of time. The WG concludes that the scientific evidence is insufficient to recommend for or against replacing running shoes for the prevention of injuries at a specified mileage interval. The WG recommends that this specific research question be addressed.

v. WARM-UP AND COOL-DOWN BEFORE AND AFTER ACTIVITY (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence of the effectiveness of warm-up and cool-down on the prevention of injuries is lacking; therefore, the JSPTIPWG cannot recommend for or against this intervention. The WG recommends that this specific research question be studied in military populations.

vi. PLACE SHORTER SERVICE MEMBERS IN FRONT OF FORMATIONS TO SET RUNNING PACE AND CADENCE (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence that placing Service members in ranks from front to back by their physical height as an intervention strategy to prevent lower extremity injuries is weak; therefore, the JSPTIPWG cannot recommend for or against this intervention. The WG recommends that a randomized trial be performed to definitively test this hypothesis and the impact this intervention may have on taller Service members.

vii. MANIPULATE STRIDE LENGTH (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence that stride-length manipulation is a cause of lower extremity injuries is lacking or of poor quality; therefore, the WG concludes that the evidence is insufficient to recommend for or against allowing Service members to run at a self-chosen stride length for the prevention of injuries. Additionally, research to date does not indicate that a self-chosen stride length causes any harm.

Therefore, the JSPTIPWG recommends that this specific intervention be addressed by research or program evaluation.

viii. PARTICIPATE IN A STANDARDIZED, GRADUATED MARCHING (HIKING) PROGRAM (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence that a standardized, graduated marching (hiking) program is effective is lacking; therefore, the JSPTIPWG cannot recommend for or against a standardized graduated marching (hiking) program alone for the prevention of injuries. The WG recommends that this specific research question be addressed.

ix. GRADUALLY INCREASE LOAD-BEARING DURING MARCHING (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence that a gradual application of load-bearing reduces injuries is lacking; therefore, the WG cannot recommend for or against the gradual application of load bearing for the prevention of injuries in basic military training. The JSPTIPWG recommends that this specific research question be addressed.

x. AVOID HAZARDOUS EXERCISES OR EXERCISE MACHINES (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence of the effectiveness of eliminating or avoiding any specific exercise or exercise machine as an injury prevention intervention is lacking; therefore, the JSPTIPWG cannot recommend for or against eliminating or avoiding any specific exercise or exercise machine to prevent injuries. The WG recommends that research on specific exercises or exercise machines reputed to either cause injury or aggravate existing injuries be addressed individually through research or program evaluation.

xi. SEPARATE BODY WEIGHT ASSESSMENT AND MAXIMAL EFFORT PHYSICAL FITNESS TESTS (*INSUFFICIENT EVIDENCE TO SUPPORT*). Evidence that disassociating body weight assessment and a maximal effort physical fitness testing is an effective injury prevention strategy is lacking; therefore, the JSPTIPWG cannot recommend for or against disassociating body weight assessment and a maximal effort physical fitness test as a means to avoid injury. The WG recommends that this specific research question be addressed.

xii. WEAR SHOCK-ABSORBING INSOLES (*INSUFFICIENT EVIDENCE TO SUPPORT*). The JSPTIPWG found mixed evidence that shock-absorbing insoles can reduce injuries and concludes that the balance of benefits and cost is too close to justify a general recommendation for all Service members. Insoles may be appropriate for older running shoes, military combat boots, or high risk populations only. The WG cannot make a general recommendation for or against the use of shock-absorbing insoles for the prevention of injuries in the general Service member population. Therefore, the WG recommends further research on shock-absorbing insoles as a prevention strategy with specific footwear or in select populations.

xiii. WEAR RUNNING SHOES BASED ON INDIVIDUAL FOOT SHAPE (*INSUFFICIENT EVIDENCE TO SUPPORT*). The popular practice of fitting the foot with a running shoe that is purported to be appropriate for a particular foot type (as measured by a static imprint of the foot) to prevent foot

and lower extremity injury has not been conclusively demonstrated to prevent injuries. Therefore, the JSPTIPWG recommends that this specific research question be addressed and compared with other dynamic (movement) methods of foot measurement for running shoe type.

xiv. WRAP ANKLE WITH ATHLETIC TAPE PRIOR TO HIGH-RISK ACTIVITY (INSUFFICIENT EVIDENCE TO SUPPORT). Evidence that ankle taping is an effective injury prevention strategy is lacking; therefore, the JSPTIPWG cannot recommend for or against ankle taping for the prevention of ankle sprain injuries. Since implementation of this particular intervention in the military is very likely impractical, the WG recommends that research addressing feasibility and practicality be conducted including possibly targeting specific military populations where the need for ankle support may be great enough to merit taping (provided there is skilled operator support for such an intervention).

xv. RUN ON IMPROVED SURFACES THAT MINIMIZE INJURY RISK (INSUFFICIENT EVIDENCE TO SUPPORT). Evidence of the effectiveness of certain running surfaces on injury risk is lacking, of poor quality, or conflicting and the balance of benefits and harms cannot be determined. The JSPTIPWG, therefore, concludes that the evidence is insufficient to recommend for or against any particular running surface for the prevention of injuries. The WG recommends that this specific research question be addressed.

xvi. IMPROVE OBSTACLE COURSE LANDING SURFACES (INSUFFICIENT EVIDENCE TO SUPPORT). The JSPTIPWG found at least fair risk factor evidence that shredded rubber material attenuates shock better than other materials and is associated with fewer civilian playground injuries in children, but the evidence that shredded rubber on military obstacle course landing surfaces prevents injury is lacking. Therefore, the JSPTIPWG concludes that the evidence is insufficient to recommend for or against use of this material on military obstacle course landing surfaces to prevent injuries. The WG strongly recommends that this specific research question be addressed.

xvii. ADJUST TRAINING LOADS BY SEASONAL VARIATIONS (INSUFFICIENT EVIDENCE TO SUPPORT). Evidence for the effectiveness of seasonally adjusting physical training load is weak, and the balance of benefits and harms cannot be determined. The JSPTIPWG, therefore, concludes that the evidence is insufficient to recommend seasonal adjustments of training load to prevent musculoskeletal injuries. The WG recommends that investigations be conducted to conclusively evaluate the association between environmental temperature and overall musculoskeletal injury incidence and evaluate the unintended consequences to military units of adjusting physical training according to thermal environmental conditions.

xviii. ENCOURAGE SMOKING CESSATION PROGRAMS TO PREVENT MUSCULOSKELETAL INJURIES (INSUFFICIENT EVIDENCE TO SUPPORT). Smoking has been identified as a strong risk factor for musculoskeletal injury. There is sufficient retrospective evidence that quitters have an injury rate that is greater than nonsmokers but less than smokers, suggesting that quitters can

reduce their injury risk. In the absence of convincing observational studies, the JSPTIPWG concludes that the evidence is insufficient to recommend for or against smoking cessation programs for the purpose of preventing injuries. However, there are many other well-documented benefits of smoking cessation. The WG strongly recommends that the association between smoking cessation and decreased musculoskeletal injury risk be assessed through large-scale observational studies at a minimum.

xix. EDUCATE SERVICE MEMBERS ON SAFE-LIFTING TECHNIQUES (INSUFFICIENT EVIDENCE TO SUPPORT). The JSPTIPWG concludes that the evidence is insufficient to recommend for or against safe-lifting technique education for the prevention of injuries in healthy individuals as an isolated intervention. Evidence that isolated safe-lifting technique education for healthy individuals effectively reduces injury or minimizes injury risk is lacking or of poor quality. Safe-lifting technique education may be an effective adjunct to multi-intervention injury prevention programs. The WG recommends higher quality research to determine the influence of safe-lifting technique training on injury risk as a primary prevention measure as well as among subcategories of those who have been diagnosed with nonspecific low back pain.

xx. APPLY ICE TO INJURIES EARLY TO PREVENT RE-INJURY (INSUFFICIENT EVIDENCE TO SUPPORT). While cryotherapy has been helpful as a treatment modality affecting swelling, pain, range of motion, and so forth, the JSPTIPWG concludes that the evidence is insufficient to recommend for or against use of cryotherapy for secondary prevention of injury (or reinjury) or to speed return to activity. The WG recommends that randomized, controlled clinical studies be conducted to assess the efficacy of the application of ice after injury as an injury prevention measure.

xxi. TAKE ORAL CONTRACEPTIVES TO DECREASE INJURY (INSUFFICIENT EVIDENCE TO SUPPORT). The JSPTIPWG concludes that the evidence is insufficient to recommend for or against oral contraceptive usage to prevent injuries in women. The WG recommends that this specific research question be addressed through detailed observational studies.

xxii.. STANDARDIZE UNIT RECONDITIONING PROGRAM AFTER REHABILITATION (INSUFFICIENT EVIDENCE TO SUPPORT). The JSPTIPWG concludes that the evidence is insufficient to recommend for or against a standardized unit reconditioning program for the prevention of reinjury. While substantial evidence exists for the benefits of rehabilitation for specific injuries, evidence that a standardized reconditioning program for groups is effective is lacking. Therefore, the WG recommends that a standardized injury reconditioning program to prevent reinjury be developed and evaluated for effectiveness in the prevention of injuries in group military training.

xxiii. PREDICT INJURY RISK THROUGH USE OF AN INJURY RISK INDEX (INSUFFICIENT EVIDENCE TO SUPPORT). The JSPTIPWG recommends exploring the development of an injury risk index. Detailed statistical modeling techniques should be used to develop a multivariate

injury risk index utilizing known risk factors for musculoskeletal injury for the purpose of identifying those at greatest risk, then target interventions to reduce that risk. The WG did not find any composite musculoskeletal injury risk index in the literature. However, the WG did find at least fair evidence that certain tests are predictive of specific injuries and that screening for risk factors may allow for interventions that reduce the overall risk.

(E) INTERVENTIONS WITHOUT A COMPLETED REVIEW (INTERVENTIONS THAT REQUIRE A SYSTEMATIC LITERATURE REVIEW, WG DISCUSSION, AND OBJECTIVE ASSESSMENT).

i. PROVIDE PRE-BASIC TRAINING FITNESS ASSESSMENT AND FITNESS PROGRAMS FOR THE LEAST FIT (*INCOMPLETE REVIEW*). Despite recent studies showing a pre-basic combat training fitness assessment and physical training program to be effective in lowering basic training injuries, there has been no systematic review and assessment of literature quality to make a determination on the effectiveness of this intervention for injury prevention; therefore, the JSPTIPWG concludes that the evidence is insufficient to recommend for or against this intervention. The WG recommends a complete systematic review and quality assessment of literature on preconditioning programs of aerobic and anaerobic exercise for new, very low-fit recruits who do not meet a minimum standard of fitness prior to entry into basic training.

ii. INDIVIDUALIZE PHYSICAL TRAINING VS. TRAINING AS A GROUP OR UNIT (*INCOMPLETE REVIEW*). The JSPTIPWG cannot recommend for or against the use of individualized physical training in place of training as a group or military unit since a review of the literature and a quality analysis is incomplete. The WG recommends a literature review and quality analysis be conducted on individualized physical training versus group physical training as they relate to their effect on injury rates.

iii. WEAR KNEE BRACES (*INCOMPLETE REVIEW*). The JSPTIPWG cannot recommend for or against the prophylactic use of knee braces for the prevention of injuries since a review of the literature and a quality analysis is incomplete. The WG recommends a literature review and quality analysis be conducted on the influence of knee brace use on the prevention of injuries.

iv. WEAR FOREARM OR ELBOW STRAPS (*INCOMPLETE REVIEW*). The JSPTIPWG cannot recommend for or against the prophylactic use of forearm or elbow straps for the prevention of injuries since a review of the literature and a quality analysis is incomplete. The WG recommends a literature review and quality analysis be conducted on the influence of forearm or elbow straps on the prevention of injuries.

v. UTILIZE ALLIED HEALTH PROFESSIONALS IN A PRE-MILITARY TREATMENT FACILITY (MTF) CARE SETTING (*INCOMPLETE REVIEW*). The JSPTIPWG cannot recommend for or against the utilization of allied health professionals in a pre-MTF setting to prevent injury, prevent re-injury, or hasten return to full military duty since a review of the literature and a quality analysis is incomplete. The WG recommends a review of the scientific literature and program evaluation

and business case analysis of the following types of programs to determine efficacy of primary and secondary injury prevention and DOD-wide applicability: (1) programs that bring a full range of sports medicine care in closer proximity to trainees, (2) programs that utilize athletic trainers as organic unit assets, and (3) programs that deploy physical therapists with brigade combat teams and special operations units.

vi. ACCOMMODATE FOR PSYCHOSOCIAL ISSUES RELATED TO INJURY (*INCOMPLETE REVIEW*). The JSPTIPWG recommends that a review of various psychosocial issues that are related to injury (such as, depression, anxiety, job stress, job satisfaction, and so forth) be performed and further research be conducted (as appropriate) to clearly identify what strategies may impact the reduction of musculoskeletal injury risk.

D. CONCLUSIONS.

(1) Of the 40 physical training-related injury prevention strategies reviewed in the scientific literature by the JSPTIPWG, three were determined to be critical *components* of a successful injury prevention program and not interventions in and of themselves. Therefore, rather than viewing these components as interventions, the WG agreed to classify them as “essential elements” that are necessary for the successful implementation of any injury prevention strategy. Because of lack of convincing scientific evidence for most of the strategies identified, the WG deemed it prudent to add one more essential element to the list (research and program evaluation), bringing the list of essential elements to 4 and the total intervention strategies considered to 37. The essential elements of an injury prevention program are: (1) educating Service members, especially leaders, on injury prevention principles and strategies, (2) enforcement of injury prevention policies and programs, (3) unit injury surveillance reporting, and (4) investment of greater resources in research and program evaluation of training-related injury prevention interventions.

(2) Of the 37 interventions, six were neither reviewed nor discussed by the WG. There are currently no JSPTIPWG recommendations for these interventions except that they be reviewed and discussed in a systematic manner. The remaining 31 interventions were categorized into three levels representing the strength of recommendation: (1) recommended, (2) not recommended, and (3) insufficient evidence to recommend or not recommend. Six interventions (20 percent) had strong enough evidence to become JSPTIPWG recommendations. This was an unexpectedly low number, given that the majority of the interventions proposed had been thought by some members of the JSPTIPWG to be proven effective. Leaders should implement these recommendations and monitor injury rates and physical fitness to ensure recommended strategies are having their intended effect. Two interventions (6 percent) were not recommended due to evidence of ineffectiveness or harm. Leaders should discourage the use of back braces, harnesses, or support belts and advise against the use of anti-inflammatory medication prior to exercise in their units.

(3) What stands out as a singularly important outcome of this WG effort is the significant number of interventions for which there is still insufficient evidence to recommend as injury prevention strategies to the Services at this time. Twenty-three (74 percent) of the interventions reviewed in the scientific literature cannot be recommended because of lack of evidence, poor quality evidence, conflicting evidence, or evidence of harm. Leaders should carefully weigh the benefits and costs of implementing any of these 23 unproven strategies in their units in order to conserve resources and maximize training time. For example, it would not be prudent to waste precious physical training time with group stretching given that it has no proven injury prevention efficacy.

(4) The lack of scientific evidence found on most injury prevention strategies supports the WG decision to add the fourth essential element (greater investment of resources in research and program evaluation of training-related injury prevention interventions) for successful injury prevention programs. Without further research and program evaluation of injury prevention strategies in military populations (and in comparable civilian populations), the rate of physical training-related injuries will continue to be a burden on the Services and a health threat to Force readiness. Preventing injuries will have a significant effect on military operational readiness by decreasing entry-level attrition and separation due to injury. This technical report identifies 29 injury prevention strategies that have yet to be evaluated (n=6) or have been found to have insufficient scientific evidence (n=23) to make Quad-Service recommendations. Injury researchers interested in studying the prevention of physical training-related injuries in the military should start with this list.

(5) The systematic process of evaluating interventions enabled the JSPTIPWG to build Quad-Service consensus around those injury prevention strategies that had enough scientific evidence to recommend. The use of guidelines that required a sufficient level of scientific evidence before making any recommendation was key to prioritizing the recommendations. While the initial effort of the WG sought to elucidate the proven strategies to reduce injuries in the basic training environment, the principles behind the six recommended interventions can be broadly and inexpensively applied to operational training environments among the Services with similar results.

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APPENDIX A

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5-2. PARACHUTE ANKLE BRACE: INJURY REDUCTION CAPABILITY, BREAKAGE, SERVICE MEMBER ATTITUDES, AND MODIFICATIONS TO IMPROVE BRACE EFFECTIVENESS

A. INTRODUCTION.

(1) Previous studies have shown that the parachute ankle brace (PAB) reduced injuries in Airborne training^(1,2) and among U.S. Army Rangers during Airborne operations.⁽³⁾ Despite this, use of the PAB was discontinued at the U.S. Army Airborne School (USAAS) in 2000 because of: (1) the costs of maintenance, (2) anecdotal reports that the brace increased injuries in other parts of the lower body, and (3) anecdotal reports that it complicated parachute entanglements. A study of students at USAAS compared the period of PAB use (1994–2000) with the period after the PAB was discontinued (2000–2002). This study showed that the risk of an ankle injury that required hospitalization (such as, a very serious ankle injury) was 1.7 times higher after the brace was discontinued.⁽²⁾

(2) In 2004, the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) worked with the Defense Safety Oversight Council (DSOC) and the U.S. Army Research Institute of Environmental Medicine to further examine the PAB. A systematic evaluation was undertaken to determine whether or not the brace increased injuries in other parts of the body or complicated parachute entanglements. The PAB breakages and attitudes of Service members toward the brace were also examined. This section summarizes the major results of this effort. More details are provided in the technical reports on which this summary is based.⁽⁴⁻⁶⁾

B. METHODS.

(1) The DSOC purchased batches of PABs for USAAS from April 2005 to December 2006. While these PABs were being phased into Airborne School training, the Quality Assurance Office at Fort Benning, Georgia, provided to USACHPPM a list of all injuries that occurred and Jump Closure Reports (JCR) for each jump operation. The injury list contained the type of injury, anatomic location, class number, date, and jump number (five jumps are required for Airborne qualification). The JCRs contained the date of the jump, class number, whether or not the class wore the PAB, jump number, number of students who jumped, wind speed, type of jump, time of day, and entanglements. Wind speeds were collected on the drop zone and averaged for the period of jump operations. The type of jump was either: (1) administrative-nontactical, in which the Service member jumped without any equipment other than his or her uniform, parachute, and Kevlar[®] helmet, or (2) combat load, in which a Service member jumped with uniform, parachute, Kevlar helmet, load-carrying equipment, weapons container, and rucksack. Time of day was either day or night. Entanglements involved two or more jumpers who made physical contact that interfered with their normal descent. Based on the date, class number, and jump number, which were reported in both data sources, injury cases were matched to aggregated information from JCRs, including brace status, wind speed, type of jump, time of

day, and entanglements. (Kevlar[®] is a registered trademark of E.I. DuPont de Nemours and Company and its affiliates.)

(2) In several Airborne classes conducted between June 2005 and January 2006, students completed a questionnaire after they had made four of the five parachute descents required for Airborne qualification. The survey queried students about their demographics, physical fitness, physical characteristics (height, weight), physical activity, tobacco use, injuries in the past year, injuries during jump week, PAB wear, problems with aircraft exits, and Airborne recycling. A final section solicited open-ended comments on the PAB.

(3) In addition to the data above, the Quality Assurance Office at Fort Benning returned any PABs that were no longer functional to USACHPPM. Lack of functionality was determined by the USAAS cadre as a brace that was assumed to no longer protect against ankle injury. The USACHPPM inventoried the returned braces and developed a categorization scheme based on the breakages observed.

C. RESULTS.

(1) INJURIES AND ENTANGLEMENTS.

(A) A total of 596 injuries occurred during 102,784 jumps, for an overall cumulative injury incidence of 58 injuries/10,000 jumps. Students who did not wear the PAB had a considerably higher risk of an ankle injury. Compared with students who wore the brace, students not wearing the brace were 2.00 (95 percent confidence interval (95 percent CI) = 1.32–3.02) times more likely to experience an ankle sprain, 1.83 (95 percent CI = 1.04–3.24) times more likely to experience an ankle fracture, and 1.92 (95 percent CI = 1.38–2.67) times more likely to experience an ankle injury of any type. The PAB reduced risk of ankle injuries and ankle sprains even after wind speed, night operations, and combat loads were considered in a multivariate analysis. With these factors taken into account, students not wearing the brace were 1.90 (95 percent CI = 1.24–2.90) times more likely to experience an ankle sprain, 1.47 (95 percent CI = 0.82–2.63) times more likely to experience an ankle fracture, and 1.75 (95 percent CI = 1.25–2.48) times more likely to experience an ankle injury of any type when compared with students who wore the brace.

(B) For injuries in anatomical locations other than the ankle, there were no significant differences between those who wore the brace and those who did not. The risk ratio (RR, no brace/brace) for lower body injuries exclusive of the ankle was RR = 0.92 (95 percent CI = 0.65–1.30), for lower body fractures exclusive of the ankle RR = 0.99 (95 percent CI = 0.59–1.67), and for lower body strains and sprains exclusive of the ankle RR = 1.45 (95 percent CI = 0.73–2.87).

(C) Use of the PAB was not associated with increased incidence of parachute entanglements. There were a total of 89 parachute entanglements of which 51 involved entanglements that persisted until the jumpers reached the ground. The overall incidence of entanglements was 8.7/10,000 jumps. Entanglement incidence in the brace and no-brace groups were 9.6/10,000 jumps and 7.5/10,000 jumps, respectively ($p = 0.33$). The incidence of entanglement that persisted until the jumpers reached the ground in the brace and no-brace groups was 4.2/10,000 jumps and 4.9/10,000 jumps, respectively ($p = 0.73$). There were only two injuries among entangled jumpers; both were entanglements to the ground and in neither case were the jumpers wearing the brace.

(2) QUESTIONNAIRE.

(A) The questionnaire was completed by 1,956 Service members (1,851 men, 105 women), about half of whom (55 percent) had worn the PAB on their jumps. Over 90 percent of respondents were Army men. The average \pm standard deviation (SD) age and time in service were 22 ± 4 years and 2.4 ± 2.9 years, respectively. The total sample comprised 58 percent enlisted members, 7 percent officers, and 33 percent cadets. About 8 percent reported being Airborne recycles and about 3 percent reported aircraft exit problems. Twenty-six percent were smokers. For Army men, average \pm SD push-ups, sit-ups, and 2-mile run times were 67 ± 15 repetitions, 73 ± 13 repetitions, and 13.4 ± 1.0 minutes, respectively; for Army women, these values were 51 ± 15 repetitions, 76 ± 13 repetitions, and 14.9 ± 1.3 minutes, respectively.

(B) Analysis of each risk factor by itself (univariate analysis) showed that greater risk of an injury in jump week was associated with higher rank, longer time in service, older age, Airborne recycling, greater height, more body weight, not wearing a PAB, aircraft exit problems, an injury in the past year, and (for Army men) fewer push-ups or slower 2-mile run time. All risk factors were considered together in a multivariate analysis. Multivariate analysis considering only Army men demonstrated that older age, Airborne recycling, push-ups, not wearing a PAB, aircraft exit problems, and an injury in the last year were independent injury risk factors. Multivariate analysis considering all men showed that older age, more body weight, Airborne recycling, not wearing the PAB, aircraft exit problems, and injuries in the past year were independent injury risk factors.

(C) There were 757 Service members (39 percent of those surveyed) who provided 994 open-ended comments on the PAB, with 24 percent provided by those who did not wear the brace and 76 percent provided by those who did wear the brace. Among those who did not wear the brace, 30 percent of comments were positive, 51 percent were negative, and 19 percent were neutral. Among those who did wear the brace, 47 percent of comments were positive, 50 percent were negative, and 3 percent were neutral. The largest single category of negative comments among brace wearers had to do with design issues, accounting for 33 percent of all negative comments by brace wearers. Other categories with large numbers of negative comments had to do with comfort (16 percent), general comments (16 percent), and parachute landing falls (14

percent). Negative comments among those who did not wear the brace were more vague: 24 percent had to do with a general negative opinion of the brace, 23 percent said that they would not recommend that the Army use the PAB, and 10 percent said they would not choose to use the brace themselves. Specific comments are listed in the technical report.⁶

(3) PAB BREAKAGES.

(A) A total of 1,668 individual ankle braces (single braces, not pairs) with breakages were returned to USACHPPM. There were 1,356 PABs with one breakage location, 271 with two breakage locations, 37 with three breakage locations, and 4 with four breakage locations. Thus, there were a total of 2,025 individual breakage events. Plastic shells, ankle straps, and heel straps accounted for 14 percent, 27 percent, and 59 percent of the breakages, respectively.

(B) The areas with the greatest number of breakages were (in order of frequency): (1) the Velcro[®] portion of the heel strap, (2) the center of the heel strap, (3) the rivet/screw at the Velcro end of the heel strap, and (4) the back of the plastic shell. These four types of breakages collectively accounted for 64 percent of all the breakages. (Velcro[®] is a registered trademark of Velcro Industries, B.V.)

D. DISCUSSION.

(1) The present investigation found that the PAB protected against ankle injuries, especially ankle sprains, during military parachute training. This protective effect was manifest even after considering wind speed, time of day, and jump type—factors known to affect injury rates. Injuries to other parts of the lower body (exclusive of the ankle) were not different among those who wore the brace and those who did not. Entanglement incidence was also similar among brace wearers and nonwearers, showing that the PAB did not complicate entanglements.

(2) Airborne students who did not wear the PAB had more negative comments than those who did, indicating that Service members who wore the brace had a more favorable impression of it. General comments included simple replies such as, “I liked the brace” or “I did not like the brace.” Most negative design issues from individuals who wore the brace related to the fact that the heel strap did not seem to properly hold the PAB on the boot. Further, the PAB breakage data indicated that the majority of breakages occurred to the heel strap of the PAB. The reason for the heel strap problems was most likely the change in the military boot. The PAB was originally designed for the older black combat boot. This boot had a heel and the heel strap fit under the instep of the boot in front of the heel. This location prevented the PAB from slipping backward on the boot and the heel strap was located where it would experience minimal contact with the ground. The first “new” boot was a desert boot with a heel, so the heel strap still functioned as designed. However, about July 2005, a new desert boot with a minimal heel was issued in Army Basic Combat Training (BCT). Soldiers arriving at USAAS from BCT had this new boot. When the PAB was placed on this new boot, the heel strap could slip backward over

the heel because the heel was curved and had no instep. This caused the PAB to move backwards, so that the heel strap was now under the heel where it could be stepped on. This reduced the lifespan of the heel strap, since it was subject to abrasion from the concrete in the harness shed, asphalt on the loading ramp, and dirt on the drop zone.

(3) The brace manufacturer, in consultation with USAAS, developed a design that added buckle loops and a stabilizing strap to the PAB, as shown in Figure 5-2-1. Buckle loops are attached to the ankle strap bolts on both sides of the brace. A Velcro strap is inserted into the buckle loops and secured across the top (dorsum) of the foot. This should better hold the PAB in place, preventing it from slipping off the boot and improving the durability of the strap.



FIGURE 5-2-1. MODIFICATION FOR THE PARACHUTE ANKLE BRACE

E. RECOMMENDATIONS. The PAB should be used during military parachute training to reduce injuries. Studies in operational units should be conducted with experienced parachutists to determine whether the brace can increase operational combat capability through injury reduction. The modification to the PAB should be tested to assure that it better holds the brace on the boot and improves Service Members' attitudes toward the brace.

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5-3. INJURIES DUE TO MILITARY MOTOR VEHICLE CRASHES

A. INTRODUCTION. In Operation Iraqi Freedom and Operation Enduring Freedom from 2003 through 2006, military motor vehicles (MMVs, see Figure 5-3-1) have been responsible for 85 percent of the 1,024 Army motor vehicle crashes that have occurred.⁽¹⁾ Military combat vehicles (that is, tracked vehicles) accounted for the remaining 15 percent of motor vehicle crashes during this period. Due to differences between MMVs and privately owned vehicles (POVs) in terms of vehicle engineering and operating environment, MMVs may require different interventions to prevent injuries than those shown to be effective for POVs. The goal of this review was to identify effective interventions to prevent injuries specifically due to MMVs. This systematic review includes descriptive, analytic, and intervention studies of MMV crash-related injuries and demonstrates the need for a more evidence-based approach to MMV injury prevention.

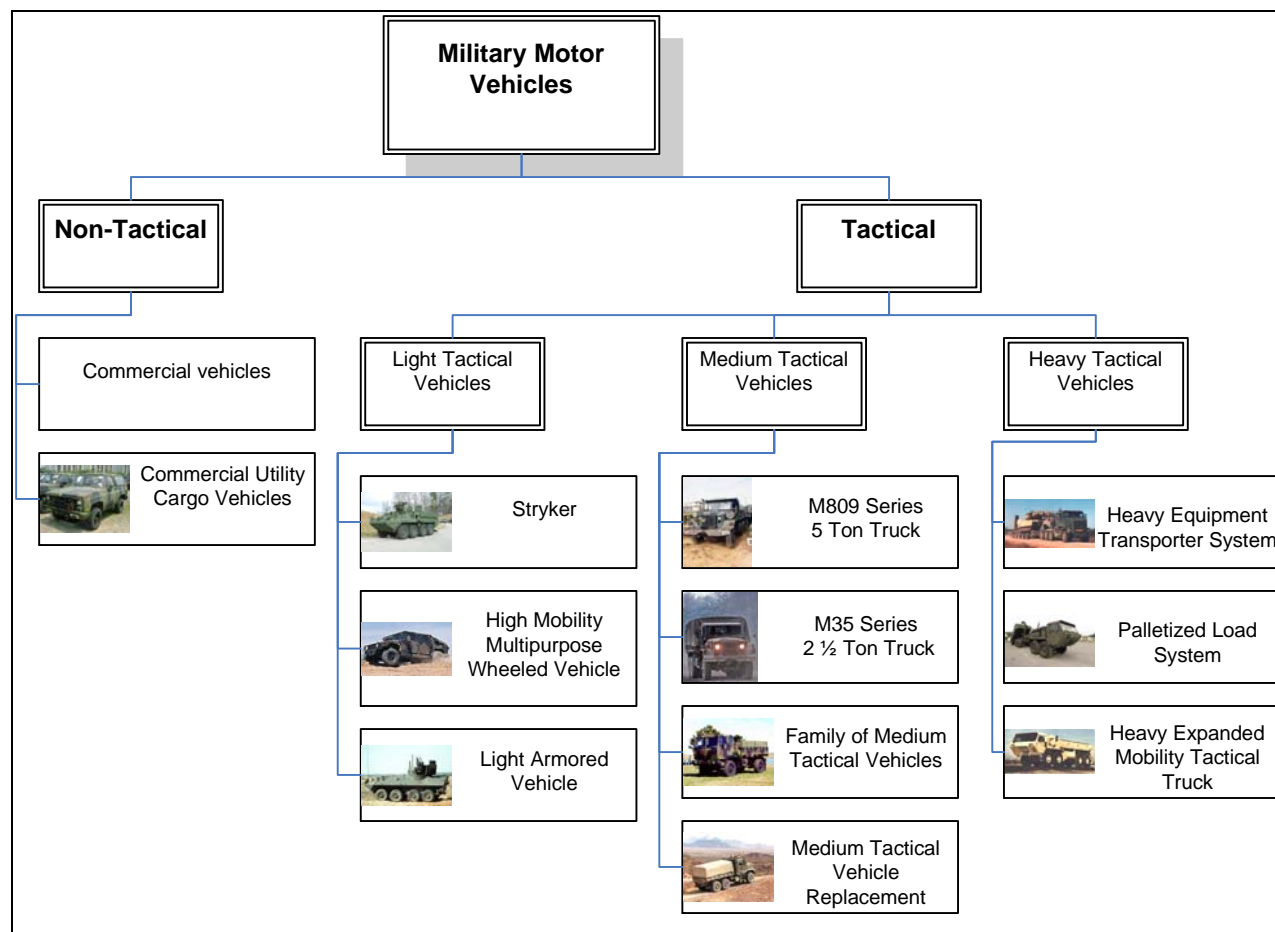


FIGURE 5-3-1. CATEGORIES OF MILITARY MOTOR VEHICLES

B. METHODS. Eighteen electronic databases were searched using the medical subject headings (or MeSH) and text words “vehicle” and “injury,” derivatives of these terms, and a combination of these terms with “military.” Since this search strategy yielded a heterogeneous mix of publications, including studies of injuries due to non-crash causes, unpublished hospitalization data on non-combat MMV-related injuries were examined to guide the selection of an appropriate focus for the systematic review. Upon Institutional Review Board approval, aggregate data on hospitalizations related to MMVs between 1996 and 2005 was received from the Defense Medical Surveillance System. Based on these data, which showed the rate for crash-related hospitalizations to be about 5 times higher than non-crash hospitalizations across all Service branches, the focus of the review was on MMV crash-related injuries. Studies were accepted for inclusion if they met the following criteria: (1) contained data on injuries resulting from MMV crashes or assessing the association between MMV crash injury and a potential risk factor, prevention strategy, or intervention; (2) written in English; and (3) publicly available between 1970 and 2006. Studies meeting these inclusion criteria were classified based on study design as case reports or case series, descriptive epidemiologic studies, analytic epidemiologic studies, or intervention studies.

C. RESULTS.

(1) The search strategy yielded 300 publications, of which only 13 met the inclusion criteria as shown in Table 5-3-1. Table 5-3-2 shows the classification of these publications by study design.

TABLE 5-3-1. SUMMARY OF PUBLISHED STUDIES MEETING INCLUSION CRITERIA, 1970 TO 2006

<i>Title</i>	<i>Authors</i>	<i>Year</i>	<i>Pub Type</i>	<i>Study Design</i>	<i>Study population</i>	<i>Outcome Measures</i>	<i>Comments</i>
Analyses of U.S. Army Accident Data	Hahn CP, et al	1971	Report	Case series	Recorded on- and off-duty crashes	Causal factor frequencies	-No comparison group -Recommended studies of risk factors
Analysis of FY79 Army Motor Vehicle Accidents	Ricketson D, Thomas MA	1980	Report	Case series	Reported crashes	Counts	-Count data -No comparison -No context to interpret trends over time
Military and civilian motor vehicle crashes with injuries in Israel: a 5 year comparison	Soudry A, Slater PE, Richter ED	1984	Journal (Travel Med Int)	Case control	Israeli Defense Force vs. Israeli civilians	Crash rates -urban vs. rural -crash type -vehicle type	-Limited generalizability
Management by objective review of Army accident experience FY84	Not listed	1984	Report	Case series	Reported crashes	Counts	-Count data -No comparison -No context to interpret trends over time
Seatbelt use in the Army	Sisk F, Ricketson DS	1985	Report	Ecologic	Drivers on-post	Severity of injury, Seatbelt usage	-Based on single data source -Poorly described methods -Ecologic fallacy
Army Safety Report FY86 Volumes 1-4*	Not listed	1986	Report	Case series -Armywide -3 subanalyses	Reported crashes	Counts	-Count data -No comparison -No context to interpret trends over time
Army Safety Report FY87	Not listed	1987	Report	Case series	Reported crashes	Counts	-Count data -No comparison -No context to interpret trends over time
New vehicle accident study	Franklin AL, et al	1991	Report	Case series -vehicle type subanalysis	Reported crashes	Causal factor frequencies	-No comparison group -No denominator -Combines MMVs and combat vehicles
Two studies of military vehicle operator selection and safety	Medsker GJ, et al	1999	Report	Case series	US Army soldiers	Personal factors assoc w/higher crash risk	-MMV/POV combined -Guidelines developed but not validated
Presentation, diagnoses, mechanism of injury, and treatment of soldiers injured in Operation Iraqi Freedom	Cohen SP, et al	2005	Journal (Anesth Analg)	Case series	OIF casualties referred to pain mgmt (n=162)	Cause of injury leading to referral	-Not specific to MMV -No comparison group

* Each volume constitutes separate publication identified by our search, resulting in total n=13.

TABLE 5-3-2. CLASSIFICATION OF ARTICLES BY STUDY DESIGN AND YEAR OF PUBLICATION

<i>Year of publication</i>	<i>Case Reports/ Series</i>	<i>Descriptive Epi Studies</i>	<i>Analytic Epi Studies</i>	<i>Intervention Studies</i>	<i>Total</i>
1970-1979	0	1	0	0	1
1980-1989	7	0	1	1	9
1990-1999	1	0	1	0	2
2000-2006	0	1	0	0	1
Total	8	2	2	1	13

(2) Rates of MMV crashes are not well-defined, in terms of numerator and denominator data, in the published literature. Annual reports of Army Safety Center data⁽²⁻⁸⁾ constitute the bulk of the published data identified by the literature search. They report rates of mishaps and fatalities per 100,000 miles driven but only span the years 1983 to 1987. Rates of mishaps were stable over the years reported, but rates of fatalities decreased by about 50 percent over this same period. Soudry et al.,⁽⁹⁾ compared rates of motor vehicle crashes involving Israeli Defense Force vehicles to civilian Israeli vehicles from 1978 to 1981 and found that military crash rates were higher for all crash types with a crash rate ratio of 13.6. However, these findings have limited generalizability. An additional case series⁽¹⁰⁾ of Army Safety Center data from 1981 to 1987 showed an upward trend in mishap counts for six specific vehicles but did not evaluate rates.

(3) Risk factors for MMV crashes and crash-related injuries are also incompletely defined. Hahn et al.⁽¹¹⁾ analyzed Army Safety Center data for all motor vehicle accidents from fiscal year 1967 in an effort to identify risk factors for crashes. They reported that they obtained “no useful results” from their analyses. Rather than performing further analyses of Safety Center data alone, they recommended collection of additional data from smaller scale studies to answer specific questions about risk factors.

(4) The MMV materiel failures, such as brake failures or tire blowouts, prominently contributed to mishaps reported in the early Army Safety Center annual reports (28 percent of mishaps in 1979).^(3, 4) Materiel failure then decreased as a reported contributor to MMV crashes, dropping to 9 percent of mishaps in 1984 and to 7 percent by 1986 and 1987.^(4, 6, 12) Medsker et al.,⁽¹³⁾ examined driver traits that increase risk of motor vehicle crashes (either POV or MMV). Predictors of elevated accident risk included: low perceptual aptitude, poor adherence to rules and regulations, low tacit knowledge test scores, high rugged individualism interest scale scores, use of drugs/alcohol, off-duty status, late night weekend hours, and major life stressors. Cohen et al.,⁽¹⁴⁾ found that 12.3 percent of Operation Iraqi Freedom veterans referred to a tertiary pain management clinic were injured in motor vehicle crashes (unspecified vehicle type).

(5) In the only intervention study identified, Sisk and Richardson⁽¹⁵⁾ examined the use of seatbelts over a 3-year period during which seatbelt use on military bases became mandatory. The authors stated that seatbelt use increased over the 3-year period studied but provided only limited anecdotal evidence to support this statement.

D. DISCUSSION.

(1) This review revealed a paucity of published literature regarding MMV crashes. Most of the articles we identified were descriptive in nature and consisted of counts rather than rates of MMV crashes. Nonetheless, the publications and unpublished data that were reviewed clearly indicate that MMV crashes are a problem. These data represent a starting point in the public health process, which begins with problem description and risk factor identification, followed by development, implementation, and evaluation of interventions aimed at prevention. Further studies using data from multiple sources, including the Safety Centers, medical databases, police investigative reports, insurance claims data, mortality registries, and administrative data on disability or military separation, will best inform preventive intervention efforts.

(2) Given that there is some overlap between operation of MMVs and POVs, evaluation of interventions that have proven effective in POVs is reasonable to consider. Engineering approaches (such as, side airbags,⁽¹⁶⁾ electronic stability control⁽¹⁷⁾) and administrative approaches (such as, graduated driver licensing,^(18, 19) primary seat belt laws,^(20, 21) and speed limit enforcement⁽²²⁾) have been effective in the civilian population. Engineering of tactical vehicles is an essential element of long-range tactical MMV crash prevention, but the identification of potential policy changes to reduce injuries, such as modification of driver selection processes or graduated licensing of new drivers, should be high priority due to their low cost and potential for immediate impact.

(3) Safety Center statistics indicate that 25 percent of new Army recruits do not have a driver's license at the time of entry into military Service. Given that novice drivers have an elevated crash risk in their first 6 months of driving,⁽²³⁾ an intervention such as graduated driver licensing may be worth evaluating as an approach to preventing crashes in inexperienced drivers. New MMV drivers could be required to have a period of driving only under supervision and not during risky conditions, such as at night, in inclement weather, or in combat settings, until this supervisory period ended.

E. CONCLUSIONS.

(1) Essentially all information on MMV crashes is based on Service Safety Center data. These data identify that a problem exists, but there is little detail about the magnitude of the problem or modifiable risk factors. Basic epidemiologic studies are needed to gain a better understanding of this problem and guide development of preventive interventions.

(2) While basic epidemiologic studies are being conducted, interventions effective for POVs in the civilian population should be evaluated for effectiveness for MMVs. Targets of effective interventions for POVs in the civilian population are predominantly engineering of vehicles and regulatory or legislative policy.

(3) Although safety engineering features should be incorporated in tactical vehicle design when found to be effective, this approach is a long-term prevention effort. Administrative interventions may be implemented more rapidly in the military compared with civilian settings and are relatively low cost. In particular, graduated driver licensing has been shown to be effective in the civilian population and a form of this licensing for MMVs should be developed, implemented, and evaluated for effectiveness in preventing MMV crashes and reducing MMV crash-related injuries.

F. ACKNOWLEDGMENTS. We would like to thank Dr. Michelle Canham-Chervak, Ms. Nancy Morrell, Ms. Karen Chesbrough, and Mr. Barry Tanner for their assistance with study design and/or data acquisition. The views expressed are those of the authors and do not represent the official policy or position of the U.S. Department of Defense, the U.S. Navy, the Uniformed Services University of the Health Sciences, or the U.S. Government.

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5-4. INJURY REDUCTION EFFECTIVENESS OF PRESCRIBING RUNNING SHOES BASED ON PLANTAR SHAPE IN ARMY AND AIR FORCE BASIC TRAINING

A. INTRODUCTION.

(1) Running shoe companies, popular running magazines, and other publications⁽¹⁻³⁾ suggest that the shape of the plantar surface can be used as an indication of the height of the longitudinal foot arch and that the plantar shape can be used to select appropriate types of running shoes. Shoe manufacturers market three types of running shoes designed for individuals with plantar shapes indicative of high, normal, and low arches: cushion, stability, and motion control shoes, respectively. These shoes are hypothesized to reduce injuries by compensating for presumed differences in running mechanics.⁽³⁾

(2) The practice in the U.S. Army has been to prescribe running shoes to recruits entering Basic Combat Training (BCT) based on their plantar shape. On the other hand, the practice in the U.S. Air Force has been to provide a single running shoe to recruits entering Basic Military Training (BMT). The Military Training Task Force of the Defense Safety Oversight Council commissioned studies to see if the Army practice was effective in reducing injuries in basic training, and this section provides a summary of the results of these studies. More details regarding the studies can be found in the technical reports.^(4, 5)

B. METHODS.

(1) The Army and Air Force studies were designed to be complementary but were conducted independently. Both studies involved a prospective cohort design in which volunteers were randomized into either a control (C) or an experimental (E) group at the start of the investigation. The C-group subjects received a standard stability running shoe regardless of the shape of their plantar surface. The E-group subjects were provided a motion control, stability, or cushioned running shoe for plantar shapes indicative of low, normal, or high foot arches, respectively. The Army study involved new recruits at Fort Jackson, South Carolina; the Air Force study involved new recruits at Lackland Air Force Base, Texas.

(2) To determine the shape of the plantar surface, the barefoot volunteer mounted the acrylic platform of a device with a mirror that reflected the underside of the trainee's foot.⁽⁴⁾ This provided a view of the plantar surface (footprint), showing how much of the foot was in contact with the acrylic surface. Two testers made independent determinations of the plantar surface as indicative of either a high, normal, or low arch, based on templates⁽⁴⁾ more area in the middle third of the plantar surface indicated a low plantar shape and less area a high plantar shape.

(3) Shoe assignments differed for the Army and Air Force studies. For the Army study, all C-group subjects received a standard stability shoe (that is, New Balance[®] 767ST) regardless

of plantar shape. The E-subjects could select any shoe model within their assigned types. Table 5-4-1 lists the types and shoe models, along with the number of E-group subjects selecting each shoe. For the Air Force study, C subjects received a standard stability shoe (New Balance 498) regardless of plantar shape. The E-group subjects with plantar shapes indicative of low arches received a New Balance 587 (motion control shoe); E-group subjects with plantar shapes indicative of a high arches received a New Balance 755 (cushion shoe); E-group subjects with plantar shapes indicative of normal arches received a New Balance 498 (stability shoe). (New Balance® is a registered trademark of New Balance Athletic Shoe, Inc.)

TABLE 5-4-1. DISTRIBUTION OF ARMY SHOES BY TYPE AND SHOES SELECTED BY ARMY E-GROUP SUBJECTS

Shoe Type	Shoe (Brand and Model)	E Men (n)	E Women (n)
Motion Control	Asics® Gel Foundation 7	21	13
	Brooks Addiction 7	29	9
	Saucony® Grid Stabil 6	33	21
	New Balance® 857	37	1
Stability	New Balance 767ST	328	143
	Asics Gel 1120	3	0
	Asics Gel 2120	118	65
	Brooks® Adrenaline GTS6	42	16
	Brooks Adrenaline GTS7	108	46
	Nike® Structure Triax	124	3
	Saucony Grid Omni 5	43	21
	New Balance 717G4	2	1
	Nike Air Max Moto	22	43
Cushion	New Balance 755	24	1
	Asics Gel Cumulus	30	22
	Brooks Radius 6	45	28
	Nike Air Pegasus	70	26
	Saucony Grid Trigon 4	8	9
	New Balance 644	2	0

Notes:

ASICS® is a registered trademark of ASICS Corporation.

Brooks® is a registered trademark of Brook Sports, Inc.

Saucony® is a registered trademark of The Stride Rite Corporation.

New Balance® is a registered trademark of New Balance Athletic Shoe, Inc.

Nike® is a registered trademark of Nike, Inc.

(4) In order to control for other known injury risk factors, data were obtained from a variety of sources. Volunteers were administered a questionnaire that asked about tobacco use, physical activity, injury history, and (for women) menstrual history. Initial physical fitness test scores were obtained from the training units (tests were administered 1 to 4 days after arrival at the unit). Body heights and weight were obtained. The Army Medical Surveillance Activity (now the Armed Forces Health Surveillance Center) provided demographic data on each subject.

(5) The major outcome of interest was injuries experienced during basic training. The Defense Medical Surveillance System provided visit dates and International Classification of Diseases, revision 9 (ICD-9) codes, for all outpatient medical visits within the basic training timeframe for each subject. Injuries were determined based on a grouping of ICD-9 codes called the Comprehensive Injury Index. This index encompasses ICD-9 codes involving both traumatic (acute) injuries and overuse injuries due to repetitive microtrauma.⁽⁶⁾

(6) Person-time injury incidence rates (injured subjects/1000 person-days) were calculated as (subjects with ≥ 1 injury) \div (total subject time in BMT $\times 1000$). Comparisons between the E and C groups were made using a chi-square for person-time. Cox regression (a survival analysis technique) was used to examine the associations between potential injury risk factors (including group) and time to the first injury. Univariate Cox regressions were first performed to establish the association between time to first injury and levels of each potential risk factor in isolation (data not shown). Then, backward stepping multivariate Cox regressions were performed to establish the effect of group in the presence of the other significant risk factors. Individuals who attrited from training due either to discharge or recycling were considered for the time period they remained in training.

C. RESULTS.

(1) In the Army study, 2,168 men and 951 women successfully completed all parts of the investigation. In the Air Force study, 1,979 men and 723 women successfully completed the study. Table 5-4-2 shows that the injury incidence rate did not differ between the E and C groups in either the Army or the Air Force investigations.

TABLE 5-4-2. COMPARISON OF C AND E GROUPS ON INJURY INCIDENCE RATES

Service	Men				Women			
	Injury Incidence Rate (injuries/1000 person-days)		Rate Ratio-C/E (95% Confidence Interval)	p-value ^a	Injury Incidence Rate (injuries/1000 person-days)		Rate Ratio-C/E (95% Confidence Interval)	p-value ^a
	C	E			C	E		
Army	5.95	6.04	0.99 (0.86–1.13)	0.85	10.87	11.37	0.96 (0.82–1.12)	0.58
Air Force	6.43	7.04	0.91 (0.77–1.09)	0.30	10.89	12.96	0.84 (0.68–1.04)	0.11

Note: ^a Chi-square for rates.⁷

(2) Table 5-4-3 shows the results of the multivariate Cox regression controlling for other known risk factors in the statistical model. The hazard ratio indicates the injury risk in the E group relative to the injury risk in the C group. Among both genders in both the Army and Air Force studies, injury risk was slightly higher in the E group, but the difference was not statistically significant.

TABLE 5-4-3. MULTIVARIATE INJURY HAZARD RATIOS COMPARING C AND E GROUPS (COX REGRESSION)

Service	Group	Men			Women		
		n	Hazard Ratio (95% CI)	p-value	n	Hazard Ratio (95% CI)	p-value
Army	C	1054	1.00	---	458	1.00	---
	E	1070	1.01 (0.88–1.16)	0.87	444	1.07 (0.91–1.25)	0.44
Air Force	C	610	1.00	---	220	1.00	---
	E	658	1.11 (0.89–1.38)	0.35	234	1.14 (0.85–1.55)	0.38

D. DISCUSSION.

(1) The results demonstrated that prescribing running shoes based on plantar shape did not reduce the injury incidence rate in either Army BCT or Air Force BMT. There was little difference in injury risk during basic training between those who wore a standard stability shoe and those who wore a shoe designed by running shoe companies for a specific plantar shape. The fact that the Army and Air Force studies were similarly designed but conducted independently, at distinct locations and using different investigative teams reinforces the findings. Similarities in the two studies included: (1) tracking subjects in the same medical surveillance system, (2) determining and analyzing injuries in an identical manner, and (3) using the same prospective cohort design. Differences between the studies had to do with: (1) the types of shoes and (2) the nature of the training environment. The C-group subjects in the Air Force study received a New Balance 498, while C-group subjects in the Army study received a New Balance 767ST. The E-group subjects in the Air Force study received one of

only three shoes, one for each foot type. The E subjects in the Army study could select from 19 different shoes, as long as the shoe they selected had been designated as appropriate for their plantar shape. There were also differences in the Army and Air Force basic training instructional programs and length of training (6 versus 9 weeks).

(2) If the goal is injury prevention, it is not necessary to prescribe running shoes to basic training recruits based on a visual inspection of the static, weight-bearing plantar shape. Nonetheless, it is still recommended that recruits receive a new shoe on entry to basic training, since older shoes have previously been shown to be associated with increased injury risk.⁽⁸⁾

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CHAPTER 6

ESTIMATING INJURY COSTS:
THE ARMY MEDICAL COST AVOIDANCE MODEL

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6-1. ESTIMATING INJURY COSTS: THE ARMY MEDICAL COST AVOIDANCE MODEL

A. INTRODUCTION.

(1) BACKGROUND.

(A) A key to reducing health hazards in an Army materiel system is to demonstrate the costs avoided throughout the system's life-cycle by eliminating or mitigating hazards. This cost model estimates those avoidable costs, focusing on the medical cost factors that contribute to them. The type of hazard encountered and the level of risk drive the magnitude of each of these cost components.

(B) Health hazards are inherent in all U.S. Army materiel systems. If ignored, however, these hazards can cause serious injuries and illnesses to military operators, testers, maintainers and civilian testers, and maintainers throughout the life of the system. Lost-time costs are the major driver for illness and injury caused by system health hazards. In addition, the medical costs for treating those injuries and illnesses can pose significant financial burdens to the Army and Department of Veterans Affairs (VA) healthcare systems.

(C) Logistics Management Institute (LMI) initially developed a medical cost avoidance model (MCAM) to estimate the costs associated with the failure to abate or control health hazards in Army materiel systems. A March 1997 LMI report, *Estimating Costs for Health Hazards of Army Materiel*, described the model.⁽¹⁾ Another October 1998 report, *Cost Estimating Model for Army Materiel Health Hazards—Supporting Documentation*,⁽²⁾ provided documentation of the process, data elements, and data sources used to develop the cost model.

(D) This updated version of the model uses cost factors for individual health hazard types. Currently, the model calculates medical costs associated with Army materiel based on a single cost factor for all hazard types. This meant that a radiation exposure hazard and a chemical exposure hazard of the same risk would have the same total costs.

(E) The Health Hazard Assessment (HHA) Program⁽³⁾ recognized the need to refine the cost model to be hazard specific. These hazard-specific types have unique cost factors and serve as the basis for the revised model. This model revision should greatly increase the model's precision and validity and assist the HHA program in targeting the specific health hazards that most affect Soldier health and, ultimately, the Army's bottom line.

(2) PERFORMING HEALTH HAZARD ASSESSMENTS.

(A) THE ASSESSMENT PROGRAM.

i. The Army HHA Program is a medical program established in Army Regulation (AR) 40-10.⁽³⁾ The goals of the program are to identify, assess, and eliminate or control hazards associated with weapon platforms, munitions, equipment, clothing, training devices, and other materiel systems.

ii. Health hazards are inherent in all U.S. Army materiel. If ignored, these hazards can cause serious injuries and illnesses throughout a materiel system's life-cycle. The costs for treating such injuries and illnesses pose a significant financial burden on military and veteran healthcare systems, and the resulting lost time degrades productivity and unit readiness.

iii. For these reasons, health hazard experts assess new or improved materiel. The assessments currently evaluate the: (1) types of hazards that exist, (2) injuries or illnesses likely to result from the hazards, (3) level of risk for each hazard, and (4) corrective actions needed to eliminate or abate the hazard.

iv. The health hazard experts report this information to the materiel program managers, who are responsible for the development and life-cycle management of the materiel system.

v. Teams of medical subject matter experts perform the HHAs. The HHA Program Office at the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) centrally executes the program. Preventive medicine professionals assigned to installations, regional medical commands, major subordinate commands, and the Army staff provides the subject matter expertise support to the process throughout the Army.

vi. The medical subject matter experts perform HHAs in all phases of the acquisition process. Hazards eliminated or controlled early in the process will require less attention later in the life-cycle and reduce costs. Ideally, assessors address health hazards at the concept stage and manage them throughout the acquisition process. The goal is to resolve all of the health hazard issues during the program definition and risk reduction phase. The assessment process is an integral part of manpower and personnel integration (MANPRINT) assessments and is closely tied to system safety issues. The Army addresses health hazard issues at each of the milestone reviews in the acquisition process. The system program manager or other acquisition approval authority makes tradeoffs between the costs and benefits of health hazard elimination or control.

(B) HEALTH HAZARD TYPES. Table 6-1-1 defines the 18 health hazard types defined in the model. This model calculates cost information for all 18 health hazard types. See AR 40-10⁽³⁾ for descriptions of these health hazards.

TABLE 6-1-1. HEALTH HAZARD TYPES

Acceleration Shock
Blast Overpressure
Blunt Trauma
Chemical Substances
Cold Temperature Extremes
Deceleration Shock
Heat Temperature Extremes
Impulse Noise
Ionizing Radiation
Musculoskeletal Trauma
Laser Radiation
Microwave Radiation
Oxygen Deficiency
Biological Substances
Segmental Vibration
Sharp Trauma
Steady State Noise

(C) QUANTIFYING HEALTH RISK.

i. Risk, per se, is a probability statement as explained in the following; however, the term “health risk” combines the probability of exposure to a hazard and the severity of the potential consequences.

ii. The Army uses a risk assessment code (RAC) matrix to explain health risk levels as illustrated in Table 6-1-2. The first step is to estimate the hazard severity (HS)—the severity of the medical effects caused by exposure to a hazard. The next step is to estimate the hazard probability (HP)—the probability of an operator being exposed to the hazard. The matrix cell where the values for HS and HP intersect shows the appropriate RAC.

TABLE 6-1-2. RISK ASSESSMENT CODE MATRIX

Hazard Severity	Hazard Probability				
	A Frequent	B Probable	C Occasional	D Remote	E Improbable
I. Catastrophic	1	1	1	2	3
II. Critical	1	1	2	3	4
III. Marginal	2	3	3	4	5
IV. Negligible	3	5	5	5	5

Note: Source: AR 40-10⁽³⁾

iii. Table 6-1-3 provides an explanation of the HS categories.

TABLE 6-1-3. HAZARD SEVERITY CATEGORIES

Category I	Catastrophic
Category II	Critical
Category III	Marginal
Category IV	Negligible

iv. Table 6-1-4 provides an explanation of the HP levels.

TABLE 6-1-4. HAZARD PROBABILITY LEVELS

A	Frequent
B	Probable
C	Occasional
D	Remote
E	Improbable

v. The resulting RAC may range from 1 (a very high health risk) to 5 (a very low health risk). For example, a hazard of marginal severity (HS = III) with an exposure assessed as probable (HP = B) has a moderate overall risk (RAC = 3).

vi. There are often instances when it is not possible to eliminate a health hazard or even provide some hazard reduction by appropriate controls. Even with a controlled hazard, there remains some health risk. This “residual” risk is the risk that remains after controlling a health hazard. Residual risk is the probability or likelihood of injury resulting from exposure to the hazard once all recommendations to eliminate or minimize a hazard have been implemented. If a hazard remains, this residual risk lasts for the life of the system. Avoided costs are determined by subtracting the assigned residual hazard risk dollars from the assigned unabated hazard risk dollars.

(3) MEASURING HEALTH RISK.

(A) RISK ASSESSMENT.

i. As stated earlier, the term “health risk” combines the severity of the potential consequences and probability of exposure associated with a hazard. The Army HHA Program uses the RAC matrix (Table 6-1-5) and the process described in the LMI report⁽²⁾ and included in Section 6-2 for arriving at a RAC.

TABLE 6-1-5. RISK ASSESSMENT CODE MATRIX WITH HAZARD SEVERITY AND HAZARD PROBABILITY VALUES

Hazard Severity		Hazard Probability				
		Frequent	Probable	Occasional	Remote	Improbable
		A (0.9)	B (0.5)	C (0.2)	D (0.01)	E (0.001)
I (1)	Catastrophic	1	1	1	2	3
II (0.1)	Critical	1	1	2	3	4
III (0.01)	Marginal	2	3	3	4	5
IV (0.001)	Negligible	3	5	5	5	5

ii. Before assigning risk to a particular operation, assessors first determine the potential hazards operators face. Next, they assign a relative level of risk for each hazard. They follow the procedure described in the LMI report⁽²⁾ and AR 40-10⁽³⁾ and sum the risk scores for HS and HP. The total risk score determines the RAC. As previously stated, HS is a relative score of the severity of the medical effects caused by exposure to the hazard, and the second component, HP, is an assessment of the likelihood of exposure.

iii. As discussed earlier, the RAC resulting from the combination of these two components can range from 1 (a very high health risk) to 5 (a very low health risk). For example (see Table 6-1-4), a hazard of marginal severity (HS = III) with a probable exposure (HP = B) has a moderate overall risk (RAC = 3). This value is not of particular importance to the model. What are important are the two components of this RAC score, HS and HP.

(B) QUANTIFYING HS AND HP. A value for each severity and probability category was developed, based on the subjective interpretation of the written category descriptions in associated ARs, to quantify these probabilities as cost drivers in the model. These values were validated using fully qualified, experienced, practicing HHA experts from USACHPPM and are presented (Table 6-1-4) in parentheses.

B. METHODS.

(1) REVISED MODEL FOR ESTIMATING MEDICAL COSTS. The key improvements/enhancements of the revised model are—

(A) The ability to quantify hazard specific costs.

(B) The use of estimated military and veteran cost data from—

i. Military Health System (MHS) Management and Analysis Reporting Tool (MART) (M2) clinical data.⁽⁴⁾

ii. Military personnel cost data.⁽⁵⁾

iii. Historical Army Physical Disability Agency Disposition and VA disability compensation data.⁽⁶⁻⁹⁾

(2) This will assist the U.S. Army in estimating materiel system health hazard costs. The model is based on the probability of a hazard occurring and the severity of that hazard. The model outputs provide an understanding of a stated health risk and the likely monetary impact if no preventive or corrective actions occur (countermeasures are not implemented).

(3) The primary use for the model is to estimate total system medical and lost-time costs based on estimated MHS medical expenses.⁽¹⁰⁾ The materiel program manager can use this information to establish health hazard abatement priorities before system fielding and, subsequently, to assess the potential impact on military readiness.

(4) The individual outputs are useful for understanding the details of the medical cost expenditures caused by exposure to a health hazard. For example, some of the outputs may show a direct relation to military readiness. This is due to lost-time injuries or illness resulting from exposure to the hazards associated with a system and may result in extensive lost time on the job by affected soldiers. This statistic is critical from a military readiness perspective. Soldiers away from the job decrease the readiness of their units. Additionally, extensive lost time may require the unprogrammed acquisition and training of replacement personnel.

(2) COST MODEL FRAMEWORK.

(A) The LMI developed the framework for determining costs based on five potential negative outcomes resulting from hazard exposure that cause illness, injury, or death.

(B) Five basic events can occur when a Soldier becomes ill or injured—

i. Visit to a medical clinic for basic outpatient treatment, medication, and tests (Clinic Costs).

ii. Visit to a hospital for inpatient observation, emergency or definitive treatment, and more detailed tests (Hospitalization Costs).

iii. Loss of time away from the job due to clinic and hospital appointments, assignment to quarters, and inability to perform on the job (limited (temporarily restricted) duty) (Lost-Time Costs).

iv. Disability, either immediately while on Active Duty or at a later date after discharge or retirement (Disability Costs).

v. Fatality because of exposure severity or complications (Fatality Costs).

(3) MODEL APPLICATION. Cost data are expected to be obtained for a 1-year period and updated every 3 years subject to available funding. This data is used to calculate cost factors, such as incidence rates, average clinic costs, average daily hospital costs, and average salary costs. The actual cost model application uses the cost factors and system information in algorithms developed to calculate costs.

(4) MODEL LIMITATIONS. There are some limitations to the model—

(A) The model does not allow for the calculation of costs for specific military occupational specialties (MOS) (such as, 11B40, light weapons infantry).

(B) The model relies on MHS M2 medical expenses, and this could lead to potential overestimation of medical expense based on inclusion of potentially irrelevant fixed facility costs that are incorporated into the full cost estimates in the MHS M2 data.

(C) The model costs will vary from the true costs depending on the injury point of origin. This is because costs were averaged from the M2 clinical data base across treatment facility areas for the International Classification of Diseases, Ninth Revision (ICD-9), codes within each of the 18 hazard types (that is, costs extracted from a specific treatment facility could be higher or lower than the model).

(D) The model does not differentiate outside the continental United States and continental United States operational and nonoperational costs.

(E) Purchased care or non-MHS inpatient and outpatient data are not included in the model. This is care received from civilian providers reimbursed through TRICARE.

(F) Pharmaceutical and laboratory costs are included in inpatient and outpatient costs in the M2 clinical data. Separate pharmaceutical and laboratory cost data are not used because that would be double counting.

(G) Ambulatory visits are broken out into scheduled and walk-in appointments, sick call, and telephone consults; however, those appointment types were not broken out. Future models could reflect similar breakouts. Telephone consultations account for approximately 5 percent of the visits.

(H) Disability costs could possibly be overestimated, in part, because of aggregate disability compensation data received from VA and the estimation of how many personnel enter the VA disability system.

(I) The model omits Army materiel-related pollution prevention costs avoided in the estimate of medical costs. It considers only medical and lost-time costs resulting from the illness or injury caused by exposure to the hazard.

(J) The model does not account for the abatement costs associated with HHA recommendations. These costs are situation dependent and vary according to the abatement recommendations, the degree of reduction of the health hazard, and the system's life-cycle phase. Costs may include publication or labeling, protective equipment, production process changes, engineering design, operation and maintenance, retrofitting, and disposal.

(K) The model does not incorporate the costs to acquire and train replacements for personnel injured, ill, or killed. These costs could be substantial. It is recognized that costs may vary, and the system program manager is in the best position to assess the impact of those additional costs.

(L) Finally, the model does not estimate societal costs incurred because of an injury. The impact of an injury on the individual and family quality of life may be substantial from a financial as well as mental health perspective.

(5) MODEL ASSUMPTIONS. A number of assumptions were made to provide quantitative data where no historical military data existed or no explanation of actions taken was available.

(A) CLINIC VISIT TIME. The model estimates that the average time (travel from place of duty to clinic, wait at clinic and seen by a medical practitioner, travel from clinic to place of duty) for a clinic visit is 2 hours. Data from references (11) through (14) support this value.

(B) LIMITED (TEMPORARILY RESTRICTED) DUTY DURATION. The model estimates that the limited (temporarily restricted) duty duration for those individuals assigned limited (temporarily restricted) duty (a temporary work accommodation because of the injury incurred) is 15 days (~2 work weeks). Some individual limited (temporarily restricted) duty assignments may last a few days, while other limited (temporarily restricted) duty assignments may exceed 60 days.⁽¹⁵⁻¹⁷⁾ Actual limited (temporarily restricted) duty duration data were not available.

(C) QUARTERS ASSIGNMENT DURATION. The model estimates that the duration of assignment to quarters is equal to 3 days. References (16) and (18) indicate that physicians should use quarters if the individual could return to duty within 72 hours (3 days). Actual quarters' duration data were not available.

(D) CONVALESCENT LEAVE DURATION. The model estimates the length of hospital convalescent leave to be 30 days. References (16) and (18) indicate that physicians determine the leave necessary for care and treatment prescribed for recuperation and convalescence from a hospital stay. A unit commander may approve up to 30 days convalescent leave for an

individual returning to duty after an injury. This can be extended if required at the end of 30 days. Actual convalescent leave data were not available.

(E) LIMITED (TEMPORARILY RESTRICTED) DUTY. The model estimates that the productivity reduction for individuals assigned to limited (temporarily restricted) duty is equal to 30 percent. Limited (temporarily restricted) duty means, as advised by a physician, work in a capacity where the individual is unable to perform all the essential duties ,and/or work less than a full-time schedule of the position held at the time that the individual became injured.^(17, 19, 20) Actual degrees of limited (temporarily restricted) duty productivity reduction data were not available.

(F) MISSING OUTPATIENT VALUES. Medical Expense and Performance Reporting System (MEPRS) codes⁽¹⁰⁾ captured in M2 outpatient clinical data⁽⁴⁾ only contain costs if their MEPRS code begins with B, which is the designation for an ambulatory visit. The MEPRS codes beginning with A (inpatient), C (dental), D (ancillary), E (support), or F (special programs) will have a value of \$0 because their costs are captured by other clinics. Because of this, the model estimates these as missing values rather than \$0; otherwise, they would inaccurately underestimate average costs per outcome of interest.

(G) INJURY/ILLNESS INCIDENCE. The model uses the same approach as the Defense Medical Surveillance System in calculating injury/illness incidence by using a 30-day cut-off. In other words, if the same ICD-9 code occurs for the same individual within 30 days, it would be considered a follow-up visit; if it occurred more than 30 days later, it would be considered a new injury.

(H) VETERANS AFFAIRS POPULATION. The model estimates that 35 percent of the VA population is made up of Army veterans. This is because the Army military population makes up approximately 35 percent of the Department of Defense (DOD) military population.⁽⁹⁾

(I) VETERANS AFFAIRS CASES. The model estimates that, overall, approximately 55,000 new VA cases each year are Army veterans.⁽⁹⁾

(J) POPULATION BREAKOUT. The model estimates that the military population breakout for diagnoses will be similar in the future when calculating lost-time and disability costs.^(4, 9)

(K) COST CALCULATIONS. The model uses full cost data values from the M2 outpatient and inpatient clinical data, which includes the ancillary services (laboratory, radiology, pharmacy, and so forth) that have been associated with the visit.⁽⁴⁾ Within M2, this variable factors in projected cost and time to completion for patients who may not have been released or fully processed at the time of the data extraction. When the "full cost, total" value is null, the "full cost, raw" value is substituted; this value represents the cumulative cost at the time of the data extraction and is not estimated to completion.

(L) FATALITY COST. The average fatality cost from an injury was calculated from the data contained in Enclosure 7 of DOD Instruction (DODI) 6055.7.⁽²¹⁾ The model adjusts the cost data for inflation because the data in the DODI was from 1988.

(M) INFLATION. A general inflation rate may be derived from the Office of Management and Budget discount rates.⁽²²⁾ For this model, fiscal year (FY) 2005 inflation rate data were used. For example, the general inflation rate = $(1 + \text{nominal rate}) / (1 + \text{real rate}) - 1$. The model uses the average of the 10- and 30-year nominal and real interest rates to calculate the general inflation factor. The nominal rate = $(0.046 + 0.052) / 2 = 0.049$ and the real rate = $(0.025 + 0.031) / 2 = 0.028$. Using the previously developed equation: $(1 + 0.049) / (1 + 0.028) - 1 = 0.0204 = 2.04$ percent general inflation factor. The model calculates inflated values using the term $(1 + \text{Gen Inflation Factor})$ raised to Number Years power or $(1 + 0.0204)^{\text{No. Yrs.}}$.

i. An uninflated example for a 20-year life-cycle provides an uninflated \$1,000 per year cost avoidance: 20 yrs x \$1,000 per year = \$20,000. For an inflated 20 year life-cycle, an inflated \$1000 per year cost avoidance is 20 yrs x \$1,000 $(1.0204)^{20 (\text{No. Yrs.})}$ per year = \$20,000 x 1.4976 = \$29,952.

ii. The model multiplies the current 20-year calculation by 1.4976.

(6) THE MODEL DATA.

(A) PRIMARY SOURCES. The model develops cost estimates using a number of data sources. The primary sources include—

i. The MHS M2 clinical data⁽⁴⁾ which includes MHS clinical, beneficiary population, enrollment, costing, and workload data. As stated earlier, purchased care or non-MHS inpatient and outpatient data was not included in the model.

ii. Military personnel cost data.⁽⁵⁾

iii. Army Physical Disability Agency Disability Disposition and VA disability compensation data.⁽⁶⁻⁹⁾

(B) MHS M2 DATA. The M2 population, inpatient, and outpatient data for Active Duty Army beneficiaries were retrieved for FY 2003. The data elements used in the model from the M2 database⁽⁴⁾ are listed in Table 6-1-6. Pharmaceutical and laboratory costs are captured in the outpatient and inpatient full cost data elements. Army retired/disabled population was retrieved; however, the data were not used because there was no way of identifying this group within the aggregated population data.

TABLE 6-1-6. M2 BENEFICIARY POPULATION DATA ELEMENTS^a USED IN THE MODEL

INJURY PREVENTION REPORT NO. 12-HF-04MT-08, DEC 08

Beneficiary Population—DEERS	Inpatient Beneficiary Population—SIDR	Outpatient Beneficiary Population—SADR
AGE	Pseudo Sponsor ID	Pseudo Sponsor ID
BENCAT	Bed Days Civilian Hospital, Total	Encounters, Total
DODOCC	Bed Days in ICU, Total	Full Cost, Total
FM	Bed Days, Total	Price, Total
FY	Convalescent Leave Days, Total	Variable Cost, Total
GENDER	Cooperative Care Days, Total	Age
MARSTAT	Dispositions, Total	APG, Med
PSUEDOID	Full Cost, Total	APG, Med Desc
FMP	Medical Hold Days, Total	APG, E&M
CTCHDMIS	Price, Total	APG, E&M Desc
CTCHNAME	Quarter Days, Total	APG Proc 1
RACEETH	RWP, Total	APG Proc 2
GRADE	Sick Days this MTF, Total	APG Proc 3
SERVICE	Supplemental Care Days, Total	APG Proc 4
RACE	Variable Cost, Total	Beneficiary Category
	Admission Date	Catchment Area ID
	Beneficiary Category	Catchment Area Name
	Catchment Area ID	Diagnosis 1
	Catchment Area Name	Diagnosis 2
	Diagnosis 1	Diagnosis 3
	Diagnosis 2	Diagnosis 4
	Diagnosis 3	Disposition Code
	Diagnosis 4	E&M Code
	Diagnosis 5	FY
	Diagnosis 6	FM
	Diagnosis 7	FMP
	Diagnosis 8	Gender
	Disposition Status Code	Inpatient Indicator
	FY	Marital Status
	Diagnostic Related Group (DRG)	MEPRS (3) Code
	FM	Patient Category
	Procedure 3	Sponsor Pay Grade
	Procedure 4	Sponsor Service
	Procedure 5	Tmt Parent DMIS ID
	Procedure 6	Tmt Parent DMIS Name
	Procedure 7	Tmt Service Clinic
	Procedure 8	

TABLE 6-1-6. M2 BENEFICIARY POPULATION DATA ELEMENTS^a USED IN THE MODEL
(CONTINUED)

Beneficiary Population—DEERS	Inpatient Beneficiary Population—SIDR	Outpatient Beneficiary Population—SADR
	Pseudo Sponsor ID	
	FMP	
	Race	
	Sponsor Pay Grade	
	Sponsor Service	
	Tmt Parent DMIS ID	
	Tmt Parent DMIS Name	
	Service Date	
	Clinical Service, Admitting	
	Clinical Service, Dispositioning	
	Clinical Service, Second	
	Clinical Service, Third	
	Length Of Stay	Procedure 1
	Age	Procedure 2
	Gender	Procedure 3
	Marital Status	Procedure 4
	Patient Category	Pseudo Sponsor ID
	Procedure 1	Race

Notes:

^a Data Sources for Beneficiary Population data included Defense Enrollment Eligibility Reporting System (DEERS), Standard Inpatient Data Record (SIDR), and Standard Ambulatory Data Record (SADR)

(C) **MILITARY PERSONNEL COSTS.** The Army Military-Civilian Cost System (AMCOS) Lite database⁽⁵⁾ was used to determine military personnel salary costs. The AMCOS is an automated tool that helps users estimate the costs associated with personnel. It contains a comprehensive database of personnel-related cost factors. Applications include life-cycle estimation for weapon systems. Data was assessed from the AMCOS Web site 7 October 2005. Adjusted salaries were calculated for both Army officer (\$60.34 per hour) and enlisted personnel (\$35.29 per hour). Table 6-1-7 identifies specific population⁽²³⁾ and costs used for calculating salary and lost-time costs. Personnel salary costs are considered fully burdened. They include basic pay rates, military procurement, and operation and maintenance costs.

TABLE 6-1-7. ARMY POPULATION BY RANK AND AMCOS LITE PERSONNEL COST^a

Military Pay Grade	Population	AMCOS Lite Personnel Cost	Total Personnel Cost for Grade
O-10	10	\$229,450	\$2,294,500
O-9	40	\$207,210	\$8,288,400
O-8	103	\$192,086	\$19,784,858
O-7	147	\$234,309	\$34,443,423
O-6	3,805	\$195,119	\$742,427,795
O-5	9,124	\$197,795	\$1,804,681,580
O-4	14,035	\$160,565	\$2,253,529,775
O-3	24,264	\$118,844	\$2,883,630,816
O-2	9,553	\$98,082	\$936,977,346
O-1	6,704	\$81,330	\$545,236,320
WO-5	419	\$140,503	\$58,870,757
WO-4	1,598	\$125,569	\$200,659,262
WO-3	3,553	\$110,467	\$392,489,251
WO-2	4,624	\$94,659	\$437,703,216
WO-1	2,070	\$79,841	\$165,270,870
E-9	3,439	\$143,011	\$491,814,829
E-8	11,232	\$117,761	\$1,322,691,552
E-7	37,573	\$106,787	\$4,012,307,951
E-6	56,197	\$92,299	\$5,186,926,903
E-5	74,076	\$78,084	\$5,784,150,384
E-4	118,874	\$62,944	\$7,482,405,056
E-3	61,607	\$55,054	\$3,391,711,778
E-2	31,705	\$52,975	\$1,679,572,375
E-1	16,521	\$50,255	\$830,262,855
CADETS	4,101	\$18,221	\$74,724,321
Total Officer	84,150		\$10,561,012,490
Total Enlisted	411,224		\$30,181,843,683

Notes:

^a AMCOS Lite data included major cost categories of Military Personnel-Account (MPA); Operations & Maintenance, Army (OMA); and Other. More specific breakouts within these categories were listed in AMCOS and included under the MPA Category: military compensation, officer acquisition costs, other benefits, permanent change of station costs, retired pay accrual, separation costs, special pays, and training; under the OMA Category: medical support costs, morale, welfare and recreation costs, and officer acquisition costs; and under the Other Category: training.

(D) DISABILITY DATA. Disability data consisted of two types of disability and compensation: Active Duty and VA.

i. ACTIVE DUTY DISABILITY. Available Active Duty disability data was obtained from the USACHPPM Ergonomics Program staff. They requested this data from the Army Physical Disability Agency in 2001.⁽⁶⁾ The data contained historical disability data decisions from approximately 1980 to 1999. Attempts to obtain later data were not successful. The database was considered adequate because the sole purpose of obtaining it for the model was to use the data to estimate Active Duty disability-related percentages for degree of disability and disposition category.⁽²⁴⁻²⁷⁾ Four factors determine whether a Soldier's disposition is fit for duty, separation, permanent retirement, or temporary retirement. These factors include whether the Soldier can perform in his/her Military Occupational Specialty (MOS), the rating percentage, the stability of the disabling condition, and years of active service in the case of pre-existing conditions.

- **FIT FOR DUTY.** The Soldier is judged fit when he/she can reasonably perform the duties of his or her grade and MOS.
- **SEPARATION.** Separation with disability severance pay occurs if the Soldier is found unfit, has less than 20 years of active Federal service, and has a disability rating of less than 30 percent. Separation without benefits occurs if the unfitting disability existed prior to service was not permanently aggravated by military Service, and the member has less than 8 years of active service, or the disability was incurred while the Soldier was absent without leave or while engaging in an act of misconduct or willful negligence.
- **PERMANENT DISABILITY RETIREMENT.** Permanent disability retirement occurs if the Soldier is found unfit, the disability is determined permanent and stable and rated at a minimum of 30 percent, or the Soldier has 20 years of active Federal service.
- **Temporary Disability Retirement.** Temporary disability retirement occurs if the Soldier is found unfit and entitled to permanent disability retirement except that the disability is not stable for rating purposes. An individual may be on the temporary disabled retirement list (TDRL) for a maximum tenure of 5 years; however, there is no entitlement to be retained for the entire period.

ii. VETERANS AFFAIRS DISABILITY. The VA disability data was obtained from the VA Reports Control Symbol (RCS) 20-0227 report "Specific Diagnosis, Major Disability Compensation, Persian Gulf War" as of December 2003.⁽⁷⁾ This data contained the number of veterans receiving disability compensation by four digit Veterans Administration Schedule for Rating Disabilities (VASRD) code and degree of disability.

iii. ACTIVE DUTY DISABILITY COMPENSATION. Military disability compensation is based on disposition, rank, and years of service.

- For permanent retirement or placement on the TDRL, compensation is based on the higher of two computations—disability rating times retired base pay or 2.5 times years of service times retired base pay. Soldiers on the TDRL may receive no less than 50 percent or more than 75 percent of their retired base pay. The definition of retired base pay depends upon when the Soldier entered the Service. For those who entered before 8 September 1980, it is the highest basic pay received. For those who entered after 7 September 1980, it is the average of the highest individual 36 months of base pay.

- Disability severance pay equals 2 months base pay for every year of service not to exceed 12 years.

iv. VETERANS AFFAIRS DISABILITY COMPENSATION. The model uses the VA compensation rate table⁽²⁸⁾ (Table 6-1-8) that was effective 1 December 2003.

TABLE 6-1-8. VETERANS AFFAIRS
COMPENSATION RATE TABLE

Percentage ^a	Rate ^b
10%	\$106
20%	\$205
30%	\$316
40%	\$454
50%	\$646
60%	\$817
70%	\$1,029
80%	\$1,195
90%	\$1,344
100%	\$2,239

Notes:

^a Degree of disability

^b Monthly rate of compensation

(7) HEALTH HAZARD LINKS.

(A) The model links health hazards and their potential medical effects with medical outcome categories to estimated costs. It does this by linking the 18 health hazards with the ICD-9 categories (3 digit)⁽²⁹⁾ and the VASRD Codes (2 digit).⁽³⁰⁾ Appendix A contains the detailed crosswalk of the ICD-9 codes to individual health hazards; Appendix B contains the detailed crosswalk of the VASRD codes to individual health hazards.

(B) Table 6-1-9 presents the level two ICD-9 3-digit category ranges used in the model.

(C) Table 6-1-10 presents the VASRD 2-digit codes used in the model.

TABLE 6-1-9. ICD-9 CATEGORIES USED IN THE MODEL

ICD-9 Category	ICD-9 Descriptor
001-139	Infectious and Parasitic Diseases
140-239	Neoplasms
240-279	Endocrine, Nutritional, and Metabolic Diseases, and Immunity Disorders
280-289	Diseases of the Blood and Blood-Forming Organs
290-319	Mental Disorders
320-389	Diseases of the Nervous System and Sense Organs
390-459	Diseases of the Circulatory System
460-519	Diseases of the Respiratory System
520-579	Diseases of the Digestive System
580-629	Diseases of the Genitourinary System
630-677	Complications of Pregnancy, Childbirth, and the Puerperium
680-709	Diseases of the Skin and Subcutaneous Tissue
710-739	Diseases of the Musculoskeletal System and Connective Tissue
740-759	Congenital Anomalies
760-779	Certain Conditions Originating in the Perinatal Period
780-799	Symptoms, Signs, and Ill-Defined Conditions
800-999	Injury and Poisoning
V01-V83	Supplementary Classification of Factors Influencing Health Status and Contact with Health Services

TABLE 6-1-10. VASRD CODES USED IN THE MODEL

VASRD Code	VASRD Descriptor
50	Bones and Joints Disease
60	Eye and Visual Acuity
61 & 62	Ear, Smell, and Taste
63	Systemic Disease
65	Nose and Throat
66	Trachea and Bronchi
67	TB, Lungs, and Pleura
68	Non-TB Diseases
70	Heart Diseases
71	Arteries and Veins
72 & 73	Digestive System
75	Genitourinary System
76	Gynecological
77	Hemic and Lymphatic
78	Skin
79	Endocrine System
80 - 87	Organic Disease Central Nervous System
89	Epilepsies
90 & 92	Psychotic Disorders
91 & 93	Organic Brain Disorders
94 & 95	Psychoneurological Disorders
99	Dental and Oral

(8) **LOST TIME AWAY FROM WORK.** The model application identifies personnel time away from the job, an output that directly relates to unit readiness and productivity. The model can calculate lost time related to individual health hazard outcomes for—

- (A) Clinic visits.
- (B) Quarters assignment.
- (C) Hospitalization stays.
- (D) Convalescent leave.
- (E) Limited (temporarily restricted) duty.

(9) **COSTS.** Military medical care costs include the estimated expenses associated with outpatient (ambulatory) care and hospitalization. Purchased care or non-Military Health System, (MHS) inpatient and outpatient data was not included in the model. Lost-time costs include costs associated with absences from work for clinic visits, hospital stays, assignment to quarters, convalescent leave, and limited work/duty assignment. Military disability costs include costs for severance benefits, permanent and temporary disability while on Active Duty, and VA disability compensation for those individuals who may have separated or retired from the military.

(A) The overall costs include medical care (such as, clinic and hospitalization) costs; lost-time (such as, clinic visits, hospital stays, quarters, convalescent leave, and limited (temporarily restricted) duty) costs; disability costs; and fatality costs. The formula for overall costs is—

$$C_T = C_c + C_h + C_l + C_d + C_f$$

(B) Table 6-1-11 lists the overall cost elements by type, description, and source.

TABLE 6-1-11. OVERALL COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_T	Variable	Overall costs related to unabated health hazards	Calculated by model application
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model application
C_h	Variable	Cost of hospitalization (includes associated pharmaceutical and laboratory costs)	Calculated by model application
C_l	Variable	Cost of days of lost time	Calculated by model application
C_d	Variable	Cost of disability	Calculated by model application

TABLE 6-1-11. OVERALL COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE (CONTINUED)

Cost Element	Type	Description	Source
C_f	Variable	Cost of fatalities	Calculated by model application

(C) The model application calculates these costs. The formulas below present the cost elements for medical care (such as, clinic and hospitalization) costs; lost-time (such as, clinic visits, hospital stays, quarters, convalescent leave, and limited (temporarily restricted) duty) costs; disability costs; and fatality costs, while the tables describe the details of the cost elements and their source.

i. Medical Care Costs.

- Clinic Costs. The formula for clinic costs is—

$$C_c = P_e \times N_s \times N_{ps} \times S_k \times I_c \times C_a \times N_v$$

- Table 6-1-12 lists the clinic cost elements by type, description, and source.

TABLE 6-1-12. CLINIC COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_c	Variable	Cost of clinic visits (includes associated pharmaceutical and laboratory costs)	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
I_c	Constant (for each hazard)	Clinic visit incidence for injury/illness	Model application (Calculated from M2 clinical data)
C_a	Constant (for each hazard)	Average clinic visit cost (includes associated pharmaceutical and laboratory costs)	Model application (Calculated from M2 clinical data)
N_v	Constant (for each hazard)	Number of clinic visits per injury/illness (includes follow-up visits within 30 day initial visit)	Model application (Calculated from M2 clinical data and References (31), (32), and (33))

- Hospital Costs. The formula for hospitalization costs is—

$$C_h = P_e \times N_s \times N_{ps} \times S_k \times I_h \times C_{as}$$

- Table 6-1-13 lists the hospital cost elements by type, description, and source.

TABLE 6-1-13. HOSPITAL COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_h	Variable	Cost of hospitalization (includes associated pharmaceutical and laboratory costs)	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
I_h	Constant (for each hazard)	Incidence of hospitalization	Model application (Calculated from M2 clinical data)
C_{as}	Constant (for each hazard)	Average cost per hospital stay (includes associated pharmaceutical and laboratory costs)	(Calculated from M2 clinical data and References (31), (32), and (33))

ii. Lost-Time Costs.

- Total Lost-Time Costs. The formula for total lost-time costs is—

$$C_l = C_{lc} + C_{lh} + C_q + C_{ll} + C_{ld}$$

- Table 6-1-14 lists the lost-time cost elements, type, description, and sources.

TABLE 6-1-14. LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_l	Variable	Cost of days of lost time	Calculated by model application
C_{lc}	Variable	Cost of days of clinic visit lost time	Calculated by model application
C_{lh}	Variable	Cost of days of hospitalization lost time	Calculated by model application

TABLE 6-1-14. LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE (CONTINUED)

Cost Element	Type	Description	Source
C_q	Variable	Cost of days of quarters lost time	Calculated by model application
C_{ll}	Variable	Cost of days of convalescent leave lost time;	Calculated by model application
C_{ld}	Variable	Cost of days of limited (temporarily restricted) duty lost time.	Calculated by model application

- Clinic Visit Lost-Time Costs. The formula for clinic visit lost-time costs is—

$$C_{lc} = P_e \times N_s \times N_{ps} \times S_k \times S \times I_c \times N_v \times 0.25$$

- Table 6-1-15 lists the clinic visit lost-time cost elements, type, description, and sources.

TABLE 6-1-15. CLINIC VISIT LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_{lc}	Variable	Cost of days of clinic visit lost time	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
S	Constant (for each hazard)	Average salary per day per pay grade	Model application (Calculated from M2 clinical and AMCOS Lite personnel cost data)
I_c	Constant (for each hazard)	Incidence of clinic visits	Model application (Calculated from M2 clinical data)
N_v	Constant (for each hazard)	Number of clinic visits per injury/illness (includes follow-up visits within 30 day initial visit)	Model application (Calculated from M2 clinical data)
0.25	Constant (for each hazard)	Time in days for clinic visit appointment	Model assumption

iii. Hospital Stay Lost-Time Costs.

- The formula for hospital stay lost-time costs is—

$$C_{lh} = P_e \times N_s \times N_{ps} \times S_k \times I_h \times S \times H_{as}$$

- Table 6-1-16 lists the hospital stay lost-time cost elements, type, description, and sources.

TABLE 6-1-16. HOSPITAL STAY LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_{lh}	Variable	Cost days of lost time because of hospitalization	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
I_h	Constant (for each hazard)	Incidence of hospitalization	Model application (Calculated from M2 clinical data)
S	Constant (for each hazard)	Average salary per day per pay grade	Model application (Calculated from M2 clinical and AMCOS Lite personnel cost data)
H_{as}	Constant (for each hazard)	Hospital stay duration	Model application (Calculated from M2 clinical data)

- iv. Quarters Assignment Lost-Time Costs. The formula for quarters lost-time costs is—

$$C_q = P_e \times N_s \times N_{ps} \times S_k \times I_c \times S \times 0.03 \times 3$$

- Table 6-1-17 lists the quarters assignment lost-time cost elements, type, description, and sources.

TABLE 6-1-17. QUARTERS ASSIGNMENT LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_q	Variable	Cost of days of lost time because of quarters assignment	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input

TABLE 6-1-17. QUARTERS ASSIGNMENT LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE (CONTINUED)

Cost Element	Type	Description	Source
I _c	Constant (for each hazard)	Incidence of clinic visits	Model application (Calculated from M2 clinical data)
S	Constant (for each hazard)	Average salary per day per pay grade	Model application (Calculated from MHS M2 clinical and AMCOS Lite personnel cost data)
0.03	Constant (for each hazard)	Incidence for quarters assignment	Model application based on Reference (20)
3	Constant (for each hazard)	Days assigned for quarters	Model assumption based on References (16) and (18)

- Convalescent Leave Lost-Time Costs. The formula for convalescent leave lost-time costs is—

$$C_{ll} = P_e \times N_s \times N_{ps} \times S_k \times I_h \times S \times 30$$

- Table 6-1-18 lists the convalescent leave lost-time cost elements, type, description, and sources.

TABLE 6-1-18. CONVALESCENT LEAVE LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C _{ll}	Variable	Cost of days of lost time because of convalescent leave	Calculated by model application
P _e	Variable	Probability of exposure per year, based on the determined HP category	User input
N _s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N _{ps}	Variable	Number of persons per system being assessed	User input
S _k	Variable	HS factor based on the determined HS category	User input
I _h	Constant (for each hazard)	Incidence of hospitalization	Model application (Calculated from M2 clinical data)
S	Constant (for each hazard)	Average salary per day per pay grade	Model application (Calculated from M2 clinical and AMCOS Lite personnel cost data)
30	Constant (for each hazard)	Days for convalescent leave	Model assumption based on References (16) and (18)

- **Limited (Temporarily Restricted) Duty Lost-Time Costs.** The formula for limited (temporarily restricted) duty lost-time costs is:

$$C_{ld} = P_e \times N_s \times N_{ps} \times S_k \times I_c \times S \times 0.11 \times 15 \times 0.3$$

- Table 6-1-19 lists the limited (temporarily restricted) duty lost-time cost elements, type, description, and sources.

TABLE 6-1-19. LIMITED (TEMPORARILY RESTRICTED) DUTY LOST-TIME COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_{ld}	Variable	Cost of days of limited (temporarily restricted) duty lost time because of injury/ illness	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
I_c	Constant (for each hazard)	Incidence of clinic visits	Model application (Calculated from M2 clinical data)
S	Constant (for each hazard)	Average salary per day per pay grade	Model application (Calculated from M2 clinical and AMCOS Lite personnel cost data)
0.11	Constant (for each hazard)	Incidence for limited (temporarily restricted) duty assignment	Model application based on reference (20)
15	Constant (for each hazard)	Days for duration of limited (temporarily restricted) duty	Model assumption based on references (15), (16), and (17)
0.3	Constant (for each hazard)	30% work productivity reduction because of injury/illness	Model assumption

iii. DISABILITY COMPENSATION COSTS.

- **TOTAL DISABILITY COMPENSATION COSTS.** While the model calculates the total cost of each type of compensation to ensure capture of total disability compensation, it does not duplicate estimated costs. For instance, an individual cannot draw both military disability and VA disability compensation. The disability compensation costs discussed in this report are not related to concurrent receipt of military retired pay. The formula for total disability compensation costs military (Active Duty) and veteran (VA) is—

$$C_d = C_{md} + C_{vd}$$

- Table 6-1-20 lists the total disability compensation cost elements, type, description, and sources.

TABLE 6-1-20. TOTAL DISABILITY COMPENSATION COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_d	Variable	Cost of total disability	Calculated by model application
C_{md}	Variable	Cost of military Active Duty disability compensation	Calculated by model application
C_{vd}	Variable	Cost of veteran disability compensation	Calculated by model application

- Military Active Duty Disability Compensation Costs. The formula for military (Active Duty) disability compensation costs is

$$C_{md} = [P_e \times N_s \times N_{ps} \times S_k \times S \times (I_c + I_h)] \times [(I_{sb} \times C_{sb}) + (I_t \times C_t) + (I_p \times C_p)]$$

- Table 6-1-21 lists the military (Active Duty) disability compensation cost elements, type, description, and sources.

TABLE 6-1-21. MILITARY (ACTIVE DUTY) DISABILITY COMPENSATION COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_{md}	Variable	Cost of military Active Duty disability compensation	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input
S_k	Variable	HS factor based on the determined HS category	User input
S	Constant (for each hazard)	Average salary per day per pay grade	Model application (Calculated from M2 injury and AMCOS Lite personnel cost data)
I_c	Constant (for each hazard)	Incidence of clinic visits	Model application (Calculated from M2 injury data)
I_h	Constant (for each hazard)	Incidence of hospitalization	Model application (Calculated from M2 injury data)

TABLE 6-1-21. MILITARY (ACTIVE DUTY) DISABILITY COMPENSATION COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE (CONTINUED)

Cost Element	Type	Description	Source
I _{sb}	Constant (for each hazard)	Incidence of severance with benefits	Model application (Calculated from Army physical disability injury data)
C _{sb}	Constant (for each hazard)	Severance pay compensation benefit	Model application (Calculated from Army physical disability injury and compensation data)
I _t	Constant (for each hazard)	Incidence of temporary disability retirement	Model application (Calculated from Army physical disability injury data)
C _t	Constant (for each hazard)	Temporary disability compensation benefit	Model application (Calculated from Army physical disability injury and compensation data)
I _p	Constant (for each hazard)	Incidence of permanent disability retirement;	Model application (Calculated from Army physical disability injury data)
C _p	Constant (for each hazard)	Permanent disability compensation benefit	Model application (Calculated from Army physical disability injury and compensation data)

iii. VETERANS AFFAIRS DISABILITY COMPENSATION COSTS. The formula for VA disability compensation costs is—

$$C_{vd} = [P_e \times N_s \times N_{ps} \times S_k \times (I_c + I_h)] \times I_{eva} \times (I_{va} \times C_{va})$$

- Table 6-1-22 lists the VA disability compensation cost elements, type, description, and sources.

TABLE 6-1-22. VETERANS AFFAIRS DISABILITY COMPENSATION COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C _{vd}	Variable	Cost of VA disability compensation	Calculated by model application
P _e	Variable	Probability of exposure per year, based on the determined HP category	User input
N _s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N _{ps}	Variable	Number of persons per system being assessed	User input

TABLE 6-1-22. VETERANS AFFAIRS DISABILITY COMPENSATION COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE (CONTINUED)

Cost Element	Type	Description	Source
S_k	Variable	HS factor based on the determined HS category	User input
I_c	Constant (for each hazard)	Incidence of clinic visits	Model application (Calculated from M2 injury data)
I_h	Constant (for each hazard)	Incidence of hospitalization	Model application (Calculated from M2 injury data)
I_{eva}	Constant (for all hazards)	Incidence of entry into the VA system	Model application (Calculated from M2 injury and VA disability data)
I_{va}	Constant (for each hazard)	Incidence of VA disability compensation	Model application (Calculated from VA disability and compensation data)
C_{va}	Constant (for each hazard)	VA disability compensation benefit	Model application (Calculated from VA disability compensation data)

iv. FATAL INJURY COSTS. Average fatal injury costs were calculated from the data contained in Enclosure 7 of DoDI 6055.7.⁽²¹⁾ The cost was adjusted for inflation because the data in the DoDI were 1988 data. The average fatal injury cost was \$674,375 after adjusting for inflation (\$472,500 x 1.4272 (rate to inflate from 1988 to 2003)). The formula for fatal injury costs is—

$$C_f = P_e \times N_s \times N_{ps} \times S_k \times [I_c + I_h] \times I_{fi} \times C_{fi}$$

- Table 6-1-23 lists the fatal injury cost elements, type, description, and sources.

TABLE 6-1-23. FATAL INJURY COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE

Cost Element	Type	Description	Source
C_f	Variable	Cost of fatalities	Calculated by model application
P_e	Variable	Probability of exposure per year, based on the determined HP category	User input
N_s	Variable	Number of systems—the total number of individual items of materiel, equipment, or weapon systems being assessed	User input
N_{ps}	Variable	Number of persons per system being assessed	User input

TABLE 6-1-23. FATAL INJURY COST ELEMENTS, TYPE, DESCRIPTION, AND SOURCE (CONTINUED)

Cost Element	Type	Description	Source
S_k	Variable	HS factor based on the determined HS category	User input
I_c	Constant (for each hazard)	Incidence of clinic visits	Model application (Calculated from M2 clinical data)
I_h	Constant (for each hazard)	Incidence of hospitalization	Model application (Calculated from M2 clinical data)
I_{fi}	Constant (for each hazard)	Incidence of fatal injury	Model application (Calculated from MHS M2 clinical data)
C_{fi}	Constant (for each hazard)	Fatal injury cost	Model application and calculated from (reference 21)

C. **RESULTS.** Example calculations were performed using the earlier model and the current model. Table 6-1-24 presents the hazards and the RACs assigned by the health hazard assessors during their evaluation of an Army materiel system. System X, the system evaluated, had an inventory of 7,400, and each system had a crew of 4 Soldiers. The results of the new and old model calculations are presented in Tables 6-1-25 and 6-1-26.

TABLE 6-1-24. HEALTH HAZARDS AND ASSOCIATED RISK INDICES FOR SYSTEM X

Hazard Category	Hazard	Risk Assessment Code (RAC)	Hazard Severity Category	Hazard Probability
Chemical substances	Weapons combustion products	1	I	A
Chemical substances	Fire extinguishing agents	2	II	C
Chemical substances	Carbon dioxide	3	II	D
Impulse noise	Impulse noise	2	II	C
Steady-state noise	Steady-state noise	2	II	C
Cold (temperature extremes)	Cold stress	2	II	C
Heat (temperature extremes)	Heat stress	2	II	C
Oxygen deficiency	Oxygen deficiency (ventilation)	2	II	C
Laser radiation	Nonionizing radiation	2	II	C
Ionizing radiation	Ionizing radiation	4	II	E

(1) NEW MODEL.

(A) As an example, costs were estimated for an Army system (System X) evaluated by health hazard assessors, for which they wrote an HHA report. Remember that health hazards are inherent in all U.S. Army materiel systems. If ignored, however, these hazards can cause serious injuries and illnesses to military and civilian operators throughout the life of the system. In this

case, it can be seen that lost-time costs are the major driver for illness and injury caused by system health hazards. In addition, the medical costs for treating those injuries and illnesses can pose significant financial burdens to the Army and VA healthcare systems. For example, implementation of recommendations to control health hazards for this example results in avoiding potential medical and lost-time costs greater than \$50 billion over the life of the system.

(B) System X had 10 health hazards: weapons combustion products, fire extinguishing agents, carbon dioxide, impulse noise, steady-state noise, cold stress, heat stress, oxygen deficiency (ventilation), nonionizing radiation, and ionizing radiation.

(C) The model determined the costs incurred over the operational life (20 years) of the system because of unabated health hazards. An inflation factor was used. These costs are significant—in this case, greater than \$50 billion. These costs affect military readiness, productivity, and the health care system. Table 6-1-25 summarizes the medical life-cycle costs for the 10 unabated health hazards for the system. The model calculated costs for one hazard in each risk category. Health hazard intervention can reduce these costs. The application of dollar amounts to the health hazards provides new insight into areas requiring attention concerning materiel acquisition decision making.

TABLE 6-1-25. MEDICAL LIFE-CYCLE COSTS OF UNABATED HEALTH HAZARDS FOR SYSTEM X

Hazards	Costs (\$000)					
	Outpatient	Inpatient	Lost Time	Disability	Fatality	Total
Weapons combustion products	\$338,000	\$116,700	\$44,724,400	\$3,919,400	\$21,600	\$49,120,100
Fire-extinguishing agents	\$7,500	\$2,600	\$993,900	\$87,000	\$500	\$1,091,500
Carbon dioxide	\$400	\$100	\$49,700	\$4,400	\$0	\$54,600
Impulse noise	\$100	\$1,100	\$19,400	\$1,100	\$0	\$21,700
Steady-state noise	\$100	\$1,100	\$19,400	\$1,100	\$0	\$21,700
Cold stress	\$400	\$0	\$52,300	\$700	\$0	\$53,400
Heat stress	\$400	\$0	\$47,600	\$900	\$0	\$48,900
Oxygen deficiency (ventilation)	\$400	\$1,200	\$36,500	\$500	\$0	\$38,600
Nonionizing radiation	\$100	\$0	\$9,700	\$200	\$0	\$10,000
Ionizing radiation	\$0	\$0	\$6,600	\$100	\$0	\$6,700
Total	\$347,400	\$122,800	\$45,959,500	\$4,015,400	\$22,100	\$50,467,200

Note: Table totals are rounded to the nearest hundred thousand.

(D) Program managers can easily see which health hazards require immediate attention and priority abatement. They can determine whether the magnitude of the costs could have a severe impact on readiness. The avoidance of these costs can make resources available for other use—an important consideration in the current cost-constrained environment.

(E) The medical cost data clearly showed that unabated health hazards could have a significant impact on readiness and the healthcare system over the operational life of the system.

This also presents a great burden on the health care system. Health hazard intervention can reduce these costs.

(2) OLD MODEL. Table 6-1-26, using the old model, summarizes the medical life-cycle costs for the 10 unabated health hazards for the system. In this case, implementation of recommendations to control health hazards for the example results in avoiding potential medical costs greater than \$345 million over the life of the system.

TABLE 6-1-26. MEDICAL LIFE-CYCLE COSTS OF UNABATED HEALTH HAZARDS FOR THE SYSTEM USING THE EARLIER MODEL

Hazards by Rank	Costs (\$000)						
	Clinic	Hospital	Lost Time	Disability	Rehabilitation	Death	Total
Weapons combustion products	88,402	81,904	27,852	98,173	1,432	4,000	301,763
Fire extinguishing agents	1,612	1,820	619	2,182	32	0	6,265
Impulse noise	1,612	1,820	619	2,182	32	0	6,265
Steady-state noise	1,612	1,820	619	2,182	32	0	6,265
Cold stress	1,612	1,820	619	2,182	32	0	6,265
Heat stress	1,612	1,820	619	2,182	32	0	6,265
Oxygen deficiency (ventilation)	1,612	1,820	619	2,182	32	0	6,265
Nonionizing radiation	1,612	1,820	619	2,182	32	0	6,265
Carbon dioxide	81	91	31	109	2	0	314
Ionizing radiation	8	9	3	11	0	0	31
Total	99,775	94,744	32,219	113,567	1,658	4,000	345,963

D. DISCUSSION.

(1) COMPARISON OF MODELS.

(A) Table 6-1-27 summarizes the comparison of the medical life-cycle costs for the 10 unabated health hazards for the system. As previously discussed, costs were calculated for one hazard in each risk category using the old and new cost models.

TABLE 6-1-27. COMPARISON OF MEDICAL LIFE-CYCLE COSTS OF UNABATED HEALTH HAZARDS FOR SYSTEM X

Hazard	Model	Outpatient	Inpatient	Lost time	Disability	Fatality
Weapons combustion products	New	\$338,000	\$116,700	\$44,724,400	\$3,919,400	\$21,600
	Old	\$88,400	\$81,900	\$27,900	\$99,600	\$4,000
Fire extinguishing agents	New	\$7,500	\$2,600	\$993,900	\$87,000	\$500
	Old	\$1,600	\$1,800	\$600	\$2,200	\$0

TABLE 6-1-27. COMPARISON OF MEDICAL LIFE-CYCLE COSTS OF UNABATED HEALTH HAZARDS FOR SYSTEM X (CONTINUED)

Hazard	Model	Outpatient	Inpatient	Lost time	Disability	Fatality
Carbon dioxide	New	\$400	\$100	\$49,700	\$4,400	\$0
	Old	\$100	\$100	\$0	\$0	\$0
Impulse noise	New	\$100	\$1,100	\$19,400	\$1,100	\$0
	Old	\$1,600	\$1,800	\$600	\$2,200	\$0
Steady-state noise	New	\$100	\$1,100	\$19,400	\$1,100	\$0
	Old	\$1,600	\$1,800	\$600	\$2,200	\$0
Cold stress	New	\$400	\$0	\$52,300	\$700	\$0
	Old	\$1,600	\$1,800	\$600	\$2,200	\$0
Heat stress	New	\$400	\$0	\$47,600	\$900	\$0
	Old	\$1,600	\$1,800	\$600	\$2,200	\$0
Weapons combustion products	New	\$338,000	\$116,700	\$44,724,400	\$3,919,400	\$21,600
	Old	\$88,400	\$81,900	\$27,900	\$99,600	\$4,000
Fire extinguishing agents	New	\$7,500	\$2,600	\$993,900	\$87,000	\$500
	Old	\$1,600	\$1,800	\$600	\$2,200	\$0
Carbon dioxide	New	\$400	\$100	\$49,700	\$4,400	\$0
	Old	\$100	\$100	\$0	\$0	\$0

(B) The new model is an improvement over the old model because it uses estimated military medical cost data (MHS M2), clinical data,⁽⁴⁾ military personnel cost data,⁽⁵⁾ and Army Physical Disability Agency and VA disability compensation data,⁽⁶⁻⁹⁾ while the old model uses a combination of military and industry data. The algorithms in the new model are also greatly simplified because of the use of only the military data. In addition, the new model breaks out specific costs for 18 health hazards.

(C) The new model calculates medical costs based on cost factors for individual health hazard types. The earlier model calculates medical costs based on a single cost factor for all hazard types.

(D) While the results obtained from each model are different, it is difficult to make a direct comparison between the two models. The data used in the new model are not compatible with the old model because the: (1) data sources for determining costs and the algorithms for estimating costs are different; (2) health hazard types are different (new model has 18 health hazard types versus nine types in the old model); and (3) costs are specific for each of the health hazard types in the new model versus an overall average hazard cost for the old model.

(E) That said, the medical costs obtained from the new model are based primarily on military data; the medical costs from the old model were based primarily on historical Bureau of Statistics industry data. In addition, an inflation factor was incorporated into the new model; the old model did not calculate inflated costs.

(2) OLD MODEL DESCRIPTION.

(A) For the old model, incidence rates were estimate—the rate of injury or illness in a group over a period of time—based on historical industry wide data because there was very little Army data that was readily available at the time (1995–1997). The output categories for the model included clinic, hospital, lost time, disability, rehabilitation, and death. The primary data sources used were the Army Medical Surveillance Monthly Report hospitalization data; U.S. Department of Labor, Bureau of Labor Statistics lost-time data; and VA disability data. Outpatient and inpatient costs were determined based on DOD medical and dental reimbursement rates, and DOD Civilian Health and Medical Program for the Uniformed Services DRG weights along with their respective length of stay factors. Three industrial classifications (that is, construction, transportation, and service) were selected under the assumption that they could represent the range of illness and injury rates within the Army. The incidence rates for these three classifications were used as risk surrogates (that is, low, medium, and high). A USACHPPM panel of experts developed a consensus risk level for each of 15 Army system categories. Incidence rates for illness and injury, hospitalization, lost time, and disability were developed using the sources described above.

(B) The algorithms used in this model were complex because the model used industry-wide incidence rates and calculated numerous illness, injury, hospitalization, lost time, and disability factors to quantify health hazard costs. It also used population distribution factors for hospitalization, lost time, and disability to account for the variability in medical outcomes and their associated costs.

(C) The ICD-9 codes (that is, medical outcome categories) were categorized under nine health hazard types. In addition, the model combined the medical outcome categories and calculated an average health hazard cost that was the same for every health hazard. While this would lose the specific hazard costs relating to specific medical outcome categories, it was believed this approach was more feasible and would reduce error at the outset primarily because of the absence of military data.

(3) NEW MODEL DESCRIPTION.

(A) For the new model, estimated military medical cost data from MHS M2 clinical data and historical data from the Army Physical Disability Agency and VA disability compensation data were used. The output categories for the model included outpatient, inpatient, lost time, fatality, and disability. A rehabilitation category was not used as a result of not being able to determine what might be injury treatment versus rehabilitation because of an injury. Clinical data was considered as injury treatment to avoid potential duplication of costs.

(B) The algorithms used in this model were simpler than the algorithms in the old model because incidence rates and medical costs were calculated using the estimated M2 clinical data.

(C) The ICD-9 codes (that is, medical outcome categories) were categorized under 18 health hazard types.

(D) Military medical care costs include the estimated costs associated with outpatient (ambulatory) care and hospitalizations extracted from the M2 clinical database. Lost-time costs include costs associated with absences from work for clinic visits (estimated), hospital stays (from M2 clinical data), assignment to quarters (estimated), convalescent leave (estimated), and limited work/duty assignment (estimated). Military disability costs include costs for severance benefits, permanent and temporary disability while on Active Duty (from VA data), and VA disability compensation for those individuals who may have separated or retired from the military (estimated).

(E) The results of the MCAM were assessed from the perspectives of validity (Did the right things get measured?); reliability (How well can those things be measured?); practicality (Can a decision be made based on the model output?); and sensitivity (What is the impact of the model output to possible errors in the data?). Validity and reliability are relative measures, not absolute. For all of these perspectives, improvements in data collection and source data will improve the MCAM's validity.

i. VALIDITY. The model produces reasonable “real-world” results. The program applications of this model represent the basic outcomes that all prevention programs should measure. Most of the data for the model parameters are obtained from military databases. Existing databases do not relate illnesses and injuries to their “root cause.” It would be beneficial if the databases contained a field that said the injury or illness was related to operating a tank or other armored vehicle, or playing football, tennis, or combat obstacle training, and so forth. The degree of validity of the model may increase as automated military data collection and data collection systems improve. Potential indirect costs that could be incurred because of illness or injury were not included. This should not detract from the utility of the model.

- For example, some of these costs could include: (1) the costs to acquire and train personnel replacements for those soldiers injured, ill, or killed; (2) performance degradation costs or the nonmonetary effect on military readiness; (3) the costs related to the impact on family quality of life.

- It is recognized that these costs could be substantial and should be considered. It is also recognized that these costs may vary greatly. For example, it costs more to train a pilot than to train an infantryman. The system program manager is in the best position to assess the impact of these additional costs.

ii. RELIABILITY. The MCAM outputs are reliable. Its parameters are measurable or can be estimated. Assuming medical assessors perform risk assessments correctly and consistently, the model will produce the same outputs. Remember that risk assessments are subjective in nature. As assessors become more experienced, one would expect to see them assign a particular hazard the same HS, HP, and RAC. The data used in this model is primarily from military sources and is adequate to obtain quantitative cost estimates. The data for the most part is comprehensive and reliable. The data would be more reliable if the military kept records that are more accurate for quarters, convalescent leave, lost time from job, and degree and duration of limited duty. Active Duty physical disability data is limited and hard to obtain.

- The VA compensation data is only available in aggregate form. Additionally, these sources: (1) have already established collection procedures; (2) update their data periodically; and (3) make data available for use with the exception of the Active Duty physical disability data.

- Improved reliability could be achieved by having outpatient and/or inpatient medical records provide specific information concerning the “root cause” of an illness or injury. Currently, medical records contain a diagnosis but often do not contain the “root cause.” The M2 clinical data repository now has standardization agreement codes for inpatient data and a less specific cause of injury (Health Insurance Portability and Accountability Act) code for outpatient data. In the future, detailed statements annotated in medical records would improve data reliability. For example, this visit to or stay in a hospital for inpatient observation, emergency or definitive treatment, and more detailed tests was the result of an exposure to a health hazard category (such as, chemical substance) from a type of specific system (such as, armored fighting vehicle) resulting in the following diagnosis (such as, disease of the respiratory system).

iii. PRACTICALITY. The validity and reliability of the MCAM are adequate for its purpose as a cost-estimating model. Its outputs are also very practical to use and help explain what a RAC means for health hazards associated with a particular system. Greater data specificity for hazard, medical diagnosis, and MOS should improve the understanding of the monetary impact of different hazards with the same RAC. The outputs could be more practical if the military kept records that are more accurate for quarters, convalescent leave, lost time from job, and degree and duration of limited duty. This model uses 3-digit ICD-9 codes. Currently, Active Duty physical disability data is limited and has been very difficult to obtain from the Army Physical Disability Agency. The VA compensation data is only available in aggregate form. The accuracy of most of the individual measures could be improved with additional funding and improved automated data collection systems.

iv. SENSITIVITY. As previously noted, the risk assessment is subjective and can vary quite a bit based on the experience of the medical assessors. It would be reasonable to expect that variations in assigning risk codes by medical assessors would decrease with experience. Because of this concern, the model is most sensitive to the selection for HS and HP (Tables 6-1-3 and 6-

1-4). Once the matrix cell has been selected using those two factors, the model exhibits the greatest cost sensitivity to type of health hazard (Table 6-1-28).

TABLE 6-1-28. AVERAGE ESTIMATED INDIVIDUAL INJURY OR ILLNESS COSTS FOR USE IN MODEL

Hazards	Code	Outpatient Costs	Inpatient Costs	Lost-Time Costs ^a	Disability ^b	Fatality ^c	Total
Steady state noise	A	\$217.72	\$6,435.43	\$13,642.53	\$61.50	\$639,734	\$660,091.18
Impulse noise	B	\$217.72	\$6,435.43	\$13,642.53	\$63.08	\$639,734	\$660,092.76
Blast overpressure	C	\$235.60	\$6,693.55	\$21,473.33	\$263.53	\$639,734	\$668,400.01
Pathological organisms (biological substances)	D	\$219.23	\$5,703.84	\$221,233.89	\$659.28	\$639,734	\$867,550.24
Chemical substances	F	\$280.56	\$7,314.76	\$26,438.41	\$4,911.89	\$639,734	\$678,679.62
Oxygen deficiency	G	\$271.43	\$6,622.89	\$14,712.94	\$27.61	\$639,734	\$661,368.87
Ionizing radiation	H	\$311.53	\$9,624.07	\$58,141.49	\$626.48	\$639,734	\$708,437.57
Non-ionizing microwave radiation	I	\$197.18	\$12,312.69	\$11,667.53	\$14.78	\$639,734	\$663,926.18
Non-ionizing laser radiation	J	\$181.08	\$14,965.36	\$10,976.70	\$13.90	\$639,734	\$665,871.04
Acceleration shock	K	\$191.09	\$10,382.64	\$24,481.62	\$1,192.68	\$639,734	\$675,982.03
Deceleration shock	L	\$191.09	\$10,382.64	\$24,481.62	\$1,192.68	\$639,734	\$675,982.03
Heat (temperature extremes)	M	\$204.59	\$9,960.84	\$20,644.96	\$51.44	\$639,734	\$670,595.83
Cold (temperature extremes)	N	\$223.91	\$9,968.86	\$21,054.75	\$36.98	\$639,734	\$671,018.50
Blunt trauma	O	\$226.11	\$8,249.65	\$19,234.26	\$5,125.95	\$639,734	\$672,569.97
Sharp trauma	P	\$230.39	\$9,292.41	\$19,872.95	\$5,298.79	\$639,734	\$674,428.54
Musculoskeletal trauma	Q	\$209.03	\$7,706.46	\$13,323.53	\$1,035.14	\$639,734	\$662,008.16
Whole body vibration	R	\$278.58	\$7,942.07	\$13,868.22	\$427.90	\$639,734	\$662,250.77
Segmental vibration	S	\$225.39	\$7,807.54	\$13,790.12	\$469.23	\$639,734	\$662,026.28

Notes:

^a Lost-time costs were estimated based on assumptions made, M2 clinical outpatient, and inpatient clinical data.

^b Disability costs were estimated based on assumptions made and data obtained from the USACHPPM Ergonomics Program (Data from Physical Disability Agency) for Active Duty and the VA for veterans.

^c Fatality costs were estimated based on assumptions made and data contained in Enclosure 7 of DODI 6055.7.⁽²¹⁾

(F) All the algorithms are linear equations; thus, once the risk has been determined, costs are all proportional to number of systems and the number of personnel per system. Depending on the type of hazard assessed, all cost categories—outpatient, inpatient, lost time, disability, and fatality—will vary. In addition, lost-time costs can be several orders of magnitude greater than the other costs and appear to represent a major factor in cost variation.

(4) OTHER APPLICATIONS FOR THE MODEL.

(A) While the MCAM was developed for assessing the health hazards in Army materiel, it has applications that expand into other MANPRINT domains that assess health risks. For example, system safety engineers and human factors engineers could estimate medical costs for system safety and human factors engineering hazards of Army materiel.

(B) In addition, the following are examples of how the model could be used:

i. Industrial hygienists and occupational health personnel could estimate medical costs for hazards of industrial production line operations.

ii. Environmental engineers and health risk assessors could estimate medical costs for hazards associated with the cleanup of hazardous waste sites. They could also assess other environmental health hazards from environmental pollution.

iii. Preventive medicine physicians, environmental science officers, sanitary engineers, and community health nurses could estimate medical outputs for occupational and environmental hazards found in training or on the battlefield.

iv. Preventive medicine physicians, environmental science officers, sanitary engineers, and community health nurses could estimate medical outputs for determining overall medical and lost-time costs for specific disease and nonbattle injury ICD-9 codes.

v. Preventive medicine physicians, environmental science officers, sanitary engineers, and community health nurses could estimate medical outputs for determining specific MOS medical and lost-time costs for specific disease and nonbattle injury ICD-9 codes.

(5) FUTURE IMPROVEMENTS.

(A) The model still needs improvement. Any improvements are subject to the availability of funding. While this model is better than the initial model because it uses medical expenses from Army clinical data from the M2 clinical database and other military sources, incremental improvement is necessary to enable more focused cost calculations, for example, determining costs for individual MOS categories (such as, 11B40, light weapons infantry) for each of the 18 health hazards.

(B) The model relies on MHS M2 medical expenses, and this could lead to potential over-estimation of medical expense based on inclusion of potentially irrelevant fixed facility costs that are incorporated into the full cost estimates in the MHS M2 data.

(C) Another improvement would be to include purchased care costs. The inclusion of purchased care or non-MHS inpatient and outpatient data (that is, care received from civilian providers using TRICARE) should be a consideration in the future.

(D) A future model might include breakouts of ambulatory visits into scheduled and walk-in appointments, sick call, and telephone consults; costs for these separate categories would probably vary quite a bit.

(E) A future model might include the ability to perform cost-benefit analyses. To do this, one would need to account for the abatement or mitigation costs associated with HHA recommendations. These costs are situation-dependent and vary according to the abatement recommendations, the degree of reduction of the health hazard, and the system's life-cycle phase. Costs may include publication or labeling, protective equipment, production process changes, engineering design, operation and maintenance, retrofitting, and disposal. Currently, there is no single document that pulls together various abatement or mitigation costs that might be used in mitigating health hazards and health hazard exposures.

(F) Other costs that could be included in a future model would be the costs to acquire and train replacements for personnel injured, ill, or killed. These costs could be substantial. These costs may be available from AMCOS.

(G) Many assumptions were made based on available literature. Reduction of these assumptions with actual military data would greatly improve the model. Improvements could be made by the military documenting clinic visit time, limited (temporarily restricted) duty duration, quarters assignment duration, convalescent leave duration, limited (temporarily restricted) duty, and linking DOD and VA data to determine actual incidence of personnel entering into the VA system once they retire or leave military Service.

(H) Finally, the model does not estimate societal costs incurred because of an injury. The impact of an injury on the individual and family quality of life may be substantial from a financial as well as mental health perspective. Improvements in researching and obtaining these costs would be beneficial.

E. CONCLUSIONS.

(1) Quantifying health hazard costs improves the understanding of a stated health risk and assists system managers in making risk management decisions.

(2) Quantifying health hazard costs improves the system manager's understanding of the monetary impact of not implementing HHA recommendations.

(3) Using the model concept for other preventive medicine programs is feasible and highly advantageous. Exposure to the causes of injury and disease can trigger a series of possible events: clinic visits, hospitalization, lost time, disability, and fatality. These outcomes are the same as the ones used in the model.

(4) The bottom line for prevention programs is, or should be, to reduce the personal, personnel, and supply of healthcare costs of health hazards. These costs include clinic visits, hospitalization, lost time, disability, and fatality. To assess the reduction in medical costs, prevention programs can use the model outputs as performance indicators.

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6-2. ASSIGNING RISK ASSESSMENT CODES.

A. OVERVIEW.

(1) The process of assigning RACs can be subjective and variable depending upon the individual assessment of the person assigning the code. Therefore, an approach to standardizing the process and limiting the variability between individual assessors was developed. The two major factors used to determine the risk are HS and HP.

(2) Each of these factors is divided into two major components, and these components are then assigned numerical scores. The scores are then summed to obtain a total score for the HS and HP factors. These total scores are used to enter the matrix and select the appropriate RAC.

B. DETERMINING THE HAZARD SEVERITY.

(1) The HS factor is divided into two components: exposure severity and medical outcome severity. Each of the components are assigned a numerical value, and these numerical values are summed to determine the HS score. The HS scores are divided into four categories, I through IV. The HS score reflects the magnitude of the exposure to physical, chemical, or biological agents and the potential medical effects of exposure.

(2) The steps used to assign the scores follow. Use Table 6-1-1 to assign the exposure severity score.

Table 6-2-1. Determining the Exposure Severity Code

Is an alternate route of exposure possible ?	Always < AL	Occasionally > AL Always < STD	Always > AL But \leq STD	Always > STD
No	0	3	5	7
Yes	1-2	4	6	8

Notes:

AL = DOD component threshold that triggers surveillance actions. This is also called the action level. STD = DOD exposure limit, such as the threshold limit value and permissible exposure limit.

(3) Use Table 6-2-2 to assign the medical effects severity score.

Table 6-2-2. Determining the Medical Effects Severity Score

Condition	Score
No medical effect, such as nuisance noise and nuisance odor.	0
Temporary reversible illness requiring supportive treatment, such as eye irritation and sore throat.	1-2
Temporary reversible illness with a variable, but limited period of disability, such as metal fume fever.	3-4
Permanent, nonsevere illness or loss of capacity, such as permanent hearing loss.	5-6
Permanent, severe, disabling, irreversible illness or death, such as asbestosis and lung cancer.	7-8

(4) Sum the numerical scores obtained from Tables 6-2-1 and 6-2-2 to obtain the total score for the health HS factor. The total score is then converted to a severity code using Table 6-2-3.

TABLE 6-2-3. HEALTH HAZARD SEVERITY TOTAL SCORE

Total Score	Severity Code
13–16	I
9–12	II
5–8	III
0–4	IV

C. DETERMINING THE HAZARD PROBABILITY.

(1) The HP factor is divided into two major components: exposure duration and number of people exposed to the hazard. Each of the components are assigned a numerical value, and these numerical values are summed to determine the HP score. The HP score is divided into four categories, like the HS score. The four categories are designated A through D. The HP score reflects the duration of the exposure and the number of people exposed to the hazard. The steps used to assign the score follow.

(A) Determine the exposure duration score using the information presented in Table 6-2-4.

TABLE 6-2-4. DETERMINING THE EXPOSURE DURATION SCORE

Type of Exposure	1–8 Hours Per Week	> 8 Hours Per Week, Not Continuous	Continuous Exposure, Full Weekly Work Shift
Irregular, intermittent	1–2	4–6	Not applicable
Regular, periodic	2–3	5–7	8

(B) Determine the score for the number of people exposed using the information presented in Table 6-2-5.

TABLE 6-2-5. DETERMINING THE NUMBER OF EXPOSED PERSONNEL SCORE

Number of Exposed Personnel	Points
< 5	1–2
5–9	3–4
10–49	5–6
> 49	7–8

(2) Sum the scores for the exposure duration and number of people exposed from Tables 6-2-4 and 6-2-5 to obtain the total score for the HP factor. Assign the code for the HP factor based upon the information presented in Table 6-2-6.

TABLE 6-2-6. HAZARD PROBABILITY CODES

Total Points	HP Code
14–16	A
10–13	B
5–9	C
3–5	D
< 3	E

D. ASSIGNING THE RISK ASSESSMENT CODE. The RAC is assigned based upon the codes assigned to the HS and HP components of the risk. Table 6-2-7 shows the matrix used to assign the RAC.

TABLE 6-2-7. ASSIGNING THE RISK ASSESSMENT CODE

	Hazard Probability				
HS	A	B	C	D	E
I	1	1	1	2	3
II	1	1	2	3	4
III	2	3	3	4	5
IV	3	5	5	5	5

APPENDIX A

HEALTH HAZARD LINKS TO HEALTH HAZARD LINKS TO ICD-9 CODES TABLE

INJURY PREVENTION REPORT NO. 12-HF-04MT-08, DEC 08

Level 1 Code Category Number	Level 1 Codes	ICD9 Level 1	Level 2 Codes	ICD9 Level 2	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
1	001-139	INFECTIOUS AND PARASITIC DISEASES	001-009	INTESTINAL INFECTIOUS DISEASES	X						X											
1	001-139	INFECTIOUS AND PARASITIC DISEASES	010-018	TUBERCULOSIS																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	020-027	ZOONOTIC BACTERIAL DISEASES	X																	
1	001-139	INFECTIOUS AND PARASITIC DISEASES	030-041	OTHER BACTERIAL DISEASES	X																	
1	001-139	INFECTIOUS AND PARASITIC DISEASES	042	HUMAN IMMUNODEFICIENCY VIRUS (HIV) INFECTION																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	045-049	POLIOMYELITIS AND OTHER NON- ARTHROPOD-BORNE VIRAL DISEASES OF CENTRAL NERVOUS SYSTEM																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	050-057	VIRAL DISEASES ACCOMPANIED BY EXANTHEM																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	060-066	ARTHROPOD-BORNE VIRAL DISEASES	X																	
1	001-139	INFECTIOUS AND PARASITIC DISEASES	070-079	OTHER DISEASES DUE TO VIRUSES AND CHLAMYDIAE	X																	
1	001-139	INFECTIOUS AND PARASITIC DISEASES	080-088	RICKETTSIOSES AND OTHER ARTHROPOD- BORNE DISEASES	X																	
1	001-139	INFECTIOUS AND PARASITIC DISEASES	090-099	SYPHILIS AND OTHER VENEREAL DISEASES																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	100-104	OTHER SPIROCHETAL DISEASES																		

INJURY PREVENTION REPORT NO. 12-HF-04MT-08, DEC 08

Level 1 Code Category Number	Level 1 Codes	ICD9 Level 1	Level 2 Codes	ICD9 Level 2	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
1	001-139	INFECTIOUS AND PARASITIC DISEASES	110-118	MYCOSES													X					
1	001-139	INFECTIOUS AND PARASITIC DISEASES	120-129	HELMINTHIASES																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	130-136	OTHER INFECTIOUS AND PARASITIC DISEASES																		
1	001-139	INFECTIOUS AND PARASITIC DISEASES	137-139	LATE EFFECTS OF INFECTIOUS AND PARASITIC DISEASES																		
2	140-239	NEOPLASMS	140-149	MALIGNANT NEOPLASM OF LIP, ORAL CAVITY, AND PHARYNX							X											
2	140-239	NEOPLASMS	150-159	MALIGNANT NEOPLASM OF DIGESTIVE ORGANS AND PERITONEUM		X					X											
2	140-239	NEOPLASMS	160-165	MALIGNANT NEOPLASM OF RESPIRATORY AND INTRATHORACIC ORGANS		X					X											
2	140-239	NEOPLASMS	170-176	MALIGNANT NEOPLASM OF BONE, CONNECTIVE TISSUE, SKIN, AND BREAST		X					X											
2	140-239	NEOPLASMS	179-189	MALIGNANT NEOPLASM OF GENITOURINARY ORGANS		X					X											
2	140-239	NEOPLASMS	190-199	MALIGNANT NEOPLASM OF OTHER AND UNSPECIFIED SITES		X					X											
2	140-239	NEOPLASMS	200-208	MALIGNANT NEOPLASM OF LYMPHATIC AND HEMATOPOIETIC TISSUE		X					X											
2	140-239	NEOPLASMS	210-229	BENIGN NEOPLASMS		X																
2	140-239	NEOPLASMS	230-234	CARCINOMA IN SITU																		

INJURY PREVENTION REPORT NO. 12-HF-04MT-08, DEC 08

Level 1 Code Category Number	Level 1 Codes	ICD9 Level 1	Level 2 Codes	ICD9 Level 2	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
2	140-239	NEOPLASMS	235-238	NEOPLASMS OF UNCERTAIN BEHAVIOR																		
2	140-239	NEOPLASMS	239	NEOPLASMS OF UNSPECIFIED NATURE																		
3	240-279	ENDOCRINE, NUTRITIONAL AND METABOLIC DISEASES, AND IMMUNITY DISORDERS	240-246	DISEASES OF THE THYROID GLAND		X					X											
3	240-279	ENDOCRINE, NUTRITIONAL AND METABOLIC DISEASES, AND IMMUNITY DISORDERS	250-259	DISEASES OF OTHER ENDOCRINE GLANDS		X																
3	240-279	ENDOCRINE, NUTRITIONAL AND METABOLIC DISEASES, AND IMMUNITY DISORDERS	260-269	NUTRITIONAL DEFICIENCIES		X																
3	240-279	ENDOCRINE, NUTRITIONAL AND METABOLIC DISEASES, AND IMMUNITY DISORDERS	270-279	OTHER METABOLIC AND IMMUNITY DISORDERS		X					X											
4	280-289	DISEASES OF THE BLOOD AND BLOOD- FORMING ORGANS	280-289	DISEASES OF THE BLOOD AND BLOOD- FORMING ORGANS		X					X											
5	290-319	MENTAL DISORDERS	290-294	ORGANIC PSYCHOTIC CONDITIONS		X				X												
5	290-319	MENTAL DISORDERS	295-299	OTHER PSYCHOSES																		

INJURY PREVENTION REPORT NO. 12-HF-04MT-08, DEC 08

Level 1 Code Category Number	Level 1 Codes	ICD9 Level 1	Level 2 Codes	ICD9 Level 2	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
5	290-319	MENTAL DISORDERS	300-316	NEUROTIC DISORDERS, PERSONALITY DISORDERS, AND OTHER NONPSYCHOTIC MENTAL DISORDERS		X	X	X	X	X												
5	290-319	MENTAL DISORDERS	317-319	MENTAL RETARDATION		X																
6	320-389	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	320-326	INFLAMMATORY DISEASE OF THE CENTRAL NERVOUS SYSTEM																		
6	320-389	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	330-337	HEREDITARY AND DEGENERATIVE DISEASE OF THE CENTRAL NERVOUS SYSTEM		X																
6	320-389	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	340-349	OTHER DISORDERS OF THE CENTRAL NERVOUS SYSTEM		X				X						X	X	X	X	X		X
6	320-389	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	350-359	DISORDERS OF THE PERIPHERAL NERVOUS SYSTEM		X				X						X		X	X	X	X	X
6	320-389	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	360-379	DISORDERS OF THE EYE AND ADNEXA		X						X	X									
6	320-389	DISEASES OF THE NERVOUS SYSTEM AND SENSE ORGANS	380-389	DISEASES OF THE EAR AND MASTOID PROCESS		X	X	X										X	X	X		
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	390-392	ACUTE RHEUMATIC FEVER																		

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7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	393-398	CHRONIC RHEUMATIC HEART DISEASE																		
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	401-405	HYPERTENSIVE DISEASE																		
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	410-414	ISCHEMIC HEART DISEASE																		
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	415-417	DISEASE OF PULMONARY CIRCULATION		X												X	X			
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	420-429	OTHER FORMS OF HEART DISEASE		X												X	X			
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	430-438	CEREBROVASCULAR DISEASE																		
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	440-448	DISEASES OF ARTERIES, ARTERIOLES, AND CAPILLARIES												X	X				X	X
7	390-459	DISEASES OF THE CIRCULATORY SYSTEM	451-459	DISEASES OF VEINS AND LYMPHATICS, AND OTHER DISEASES OF CIRCULATORY SYSTEM																		
8	460-519	DISEASES OF THE RESPIRATORY SYSTEM	460-466	ACUTE RESPIRATORY INFECTIONS	X																	
8	460-519	DISEASES OF THE RESPIRATORY SYSTEM	470-478	OTHER DISEASES OF THE UPPER RESPIRATORY TRACT														X	X			

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8	460-519	DISEASES OF THE RESPIRATORY SYSTEM	480-467	PNEUMONIA AND INFLUENZA	X																	
8	460-519	DISEASES OF THE RESPIRATORY SYSTEM	490-496	CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND ALLIED CONDITIONS		X																
8	460-519	DISEASES OF THE RESPIRATORY SYSTEM	500-508	PNEUMOCONIOSES AND OTHER LUNG DISEASES DUE TO EXTERNAL AGENTS		X					X											
8	460-519	DISEASES OF THE RESPIRATORY SYSTEM	510-519	OTHER DISEASES OF RESPIRATORY SYSTEM		X																
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	520-529	DISEASES OF ORAL CAVITY, SALIVARY GLANDS, AND JAWS																		
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	530-537	DISEASES OF ESOPHAGUS, STOMACH, AND DUODENUM						X												
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	540-543	APPENDICITIS																		
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	550-553	HERNIA OF ABDOMINAL CAVITY																		
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	555-558	NONINFECTIOUS ENTERITIS AND COLITIS		X					X											
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	560-569	OTHER DISEASES OF INTESTINES AND PERITONEUM	X	X					X											
9	520-579	DISEASES OF THE DIGESTIVE SYSTEM	570-579	OTHER DISEASES OF DIGESTIVE SYSTEM		X					X											X
10	580-629	DISEASES OF THE	580-589	NEPHRITIS, NEPHROTIC SYNDROME, AND NEPHROSIS		X																

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10	580-629	DISEASES OF THE	590-599	OTHER DISEASES OF URINARY SYSTEM		X																
10	580-629	DISEASES OF THE	600-608	DISEASES OF MALE GENITAL ORGANS		X					X		X									
10	580-629	DISEASES OF THE	610-611	DISORDERS OF BREAST		X																
10	580-629	DISEASES OF THE	614-616	INFLAMMATORY DISEASE OF FEMALE PELVIC ORGANS																		
10	580-629	DISEASES OF THE	617-629	OTHER DISORDERS OF FEMALE GENITAL TRACT		X					X											
11	630-677		630-633	ECTOPIC AND MOLAR PREGNANCY																		
11	630-677		634-639	OTHER PREGNANCY WITH ABORTIVE OUTCOME		X					X							X	X			X
11	630-677		640-648	COMPLICATIONS MAINLY RELATED TO PREGNANCY		X												X				
11	630-677		650-659	NORMAL DELIVERY, AND OTHER INDICATIONS FOR CARE IN PREGNANCY, LABOR, AND DELIVERY ()																		
11	630-677		660-669	COMPLICATIONS OCCURRING MAINLY IN THE COURSE OF LABOR AND DELIVERY																		
11	630-677		670-677	COMPLICATIONS OF THE PUERPERIUM																		
12	680-709	DISEASES OF THE SKIN AND	680-686	INFECTIONS OF SKIN AND SUBCUTANEOUS TISSUE	X																	
12	680-709	DISEASES OF THE SKIN AND	690-698	OTHER INFLAMMATORY CONDITIONS OF SKIN AND SUBCUTANEOUS TISSUE	X	X					X					X	X					
12	680-709	DISEASES OF THE SKIN AND	700-709	OTHER DISEASES OF SKIN AND SUBCUTANEOUS TISSUE	X	X					X	X	X			X	X					

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13	710-739	DISEASES OF THE	710-719	ARTHROPATHIES AND RELATED DISORDERS														X	X	X	X	X
13	710-739	DISEASES OF THE	720-724	DORSOPATHIES														X	X	X	X	X
13	710-739	DISEASES OF THE	725-729	RHEUMATISM, EXCLUDING THE BACK																		
13	710-739	DISEASES OF THE	730-739	OSTEOPATHIES, CHONDROPATHIES, AND ACQUIRED MUSCULOSKELETAL DEFORMITIES		X								X	X							
14	740-759	CONGENITAL ANOMALIES	740-759	CONGENITAL ANOMALIES		X					X											
15	760-779	CERTAIN CONDITIONS ORIGINATING IN THE PERINATAL PERIOD (760- 779)	760-763	MATERNAL CAUSES OF PERINATAL MORBIDITY AND MORTALITY																		
15	760-779	CERTAIN CONDITIONS ORIGINATING IN THE PERINATAL PERIOD (760- 779)	764-779	OTHER CONDITIONS ORIGINATING IN THE PERINATAL PERIOD		X																
16	780-799	SYMPTOMS, SIGNS, AND ILL-DEFINED CONDITIONS	780-789	SYMPTOMS		X																
16	780-799	SYMPTOMS, SIGNS, AND ILL-DEFINED CONDITIONS	790-796	NONSPECIFIC ABNORMAL FINDINGS		X																
16	780-799	SYMPTOMS, SIGNS, AND ILL-DEFINED CONDITIONS	797-799	ILL-DEFINED AND UNKNOWN CAUSES OF MORBIDITY AND MORTALITY		X																
17	800-999	INJURY AND POISONING	800-829	FRACTURES																		

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17	800-999	INJURY AND POISONING	800-804	FRACTURE OF SKULL										X	X			X	X			
17	800-999	INJURY AND POISONING	805-809	FRACTURE OF NECK AND TRUNK										X	X			X	X			
17	800-999	INJURY AND POISONING	810-819	FRACTURE OF UPPER LIMB										X	X			X	X			
17	800-999	INJURY AND POISONING	820-829	FRACTURE OF LOWER LIMB										X	X			X	X			
17	800-999	INJURY AND POISONING	830-839	DISLOCATION										X	X			X				
17	800-999	INJURY AND POISONING	840-848	SPRAINS AND STRAINS OF JOINTS AND ADJACENT MUSCLES										X	X			X	X	X	X	X
17	800-999	INJURY AND POISONING	850-854	INTRACRANIAL INJURY, EXCLUDING THOSE WITH SKULL FRACTURE																		
17	800-999	INJURY AND POISONING	860-869	INTERNAL INJURY OF THORAX, ABDOMEN, AND PELVIS					X									X	X			
17	800-999	INJURY AND POISONING	870-897	OPEN WOUNDS		X												X	X			
17	800-999	INJURY AND POISONING	870-879	OPEN WOUND OF HEAD, NECK, AND TRUNK															X			
17	800-999	INJURY AND POISONING	880-887	OPEN WOUND OF UPPER LIMB															X			
17	800-999	INJURY AND POISONING	890-897	OPEN WOUND OF LOWER LIMB															X			
17	800-999	INJURY AND POISONING	900-904	INJURY TO BLOOD VESSELS														X	X			
17	800-999	INJURY AND POISONING	905-909	LATE EFFECTS OF INJURIES, POISONINGS, TOXIC EFFECTS, AND OTHER EXTERNAL CAUSES		X																
17	800-999	INJURY AND POISONING	910-919	SUPERFICIAL INJURY														X				
17	800-999	INJURY AND POISONING	920-924	CONTUSION WITH INTACT SKIN SURFACE														X				

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17	800-999	INJURY AND POISONING	925-929	CRUSHING INJURY														X				
17	800-999	INJURY AND POISONING	930-939	EFFECTS OF FOREIGN BODY ENTERING THROUGH ORIFICE																		
17	800-999	INJURY AND POISONING	940-949	BURNS		X					X	X	X			X	X					
17	800-999	INJURY AND POISONING	950-957	INJURY TO NERVES AND SPINAL CORD														X	X			
17	800-999	INJURY AND POISONING	958-959	CERTAIN TRAUMATIC COMPLICATIONS AND UNSPECIFIED INJURIES																		
17	800-999	INJURY AND POISONING	960-979	POISONING BY DRUGS, MEDICINAL AND BIOLOGICAL SUBSTANCES		X																
17	800-999	INJURY AND POISONING	980-989	TOXIC EFFECTS OF SUBSTANCES CHIEFLY NONMEDICINAL AS TO SOURCE		X																
17	800-999	INJURY AND POISONING	990-995	OTHER AND UNSPECIFIED EFFECTS OF EXTERNAL CAUSES												X	X					
17	800-999	INJURY AND POISONING	996-999	COMPLICATIONS OF SURGICAL AND MEDICAL CARE, NOT ELSEWHERE CLASSIFIED																		
18	V01-V83		V01-V06	PERSONS WITH POTENTIAL HEALTH HAZARDS RELATED TO COMMUNICABLE DISEASES																		
18	V01-V83		V07-V09	PERSONS WITH NEED FOR ISOLATION, OTHER POTENTIAL HEALTH HAZARDS AND PROPHYLACTIC MEASURES																		

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18	V01-V83		V10-V19	PERSONS WITH POTENTIAL HEALTH HAZARDSRELATED TO PERSONAL AND FAMILY HISTORY																		
18	V01-V83		V20-V29	PERSONS ENCOUNTERING HEALTH SERVICES IN CIRCUMSTANCES RELATED TO REPRODUCTION AND DEVELOPMENT																		
18	V01-V83		V30-V39	LIVEBORN INFANTS ACCORDING TO TYPE OF BIRTH																		
18	V01-V83		V40-V49	PERSONS WITH A CONDITION INFLUENCING THEIR HEALTH STATUS																		
18	V01-V83		V50-V59	PERSONS ENCOUNTERING HEALTH SERVICES FOR SPECIFIC PROCEDURES AND AFTERCARE																		
18	V01-V83		V60-V69	PERSONS ENCOUNTERING HEALTH SERVICES IN OTHER CIRCUMSTANCES																		
18	V01-V83		V70-V83	PERSONS WITHOUT REPORTED DIAGNOSIS ENCOUNTERED DURING EXAMINATION AND INVESTIGATION OF INDIVIDUALS AND POPULATIONS																		
19				RAILWAY ACCIDENTS																		
19				MOTOR VEHICLE TRAFFIC ACCIDENTS																		
19				MOTOR VEHICLE NONTRAFFIC ACCIDENTS																		
19				OTHER ROAD VEHICLE ACCIDENTS																		

APPENDIX B

HEALTH HAZARD LINKS TO HEALTH HAZARD LINKS TO VASRD CODES TABLE

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Major Diagnostic Code	Major Diagnosis Code	Diagnostic Code Range	Body System	Diagnostic Code	Diagnosis	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5000	Osteomyelitis, acute, subacute, or chronic																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5001	Bones and joints, tuberculosis of, active or inactive																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5002	Arthritis, Rheumatoid (Atrophic), as an active process																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5003	Arthritis, Degenerative, Hypertrophic or Osteoarthritis														X	X	X	X	X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5004	Arthritis, gonorrheal																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5005	Arthritis, pneumococcic																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5006	Arthritis, typhoid																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5007	Arthritis, syphilitic																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5008	Arthritis, streptococcic																		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5009	Arthritis, Other Types										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5010	Arthritis, Due to Trauma, substantiated by x-ray findings					X					X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5011	Bones, caisson disease of																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5012	Bones, New Growths of, Malignant		X					X											
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5013	Osteoporosis, with Joint Manifestations																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5014	Osteomalacia		X																
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5015	Bones, New Growths of, Benign		X					X											
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5016	Osteitis Deformans (Paget's Disease)																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5017	Gout		X																
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5018	Hydrarthrosis, Intermittent																		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5019	Bursitis														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5020	Synovitis														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5021	Myositis														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5022	Periostitis														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5023	Myositis Ossificans															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5024	Tenosynovitis														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5025	Fibromyalgia (fibrositis, primary fibromyalgia syndrome)														X		X	X	X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5051	Shoulder Replacement (prosthesis)																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5052	Elbow Replacement (Prosthesis)																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5053	Wrist Replacement (Prosthesis)																		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5054	Hip Replacement (Prosthesis)																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5055	Knee Replacement (Prosthesis)																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5056	Ankle Replacement (Prosthesis)																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5099	Generalized, Acute, Subacute, or Chronic Diseases of the Musculoskeletal System					X					X	X			X	X		X	X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5104	Anatomical loss of one hand and loss of use of one foot														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5105	Anatomical loss of one foot and loss of use of one hand														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5106	Anatomical loss of both hands														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5107	Anatomical loss of both feet														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5108	Anatomical loss of one hand and one foot														X	X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5109	Loss of use of both hands														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5110	Loss of use of both feet														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5111	Loss of use of one hand and one foot														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5120	Arm, amputation of, Disarticulation of Shoulder														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5121	Amputation of arm above insertion of deltoid														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5122	Amputation of arm below insertion of deltoid														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5123	Forearm, amputation of, above insertion of pronator teres														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5124	Forearm, amputation of, below insertion of pronator teres														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5125	Hand, Loss of use of												X		X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5126	Amputation of Five Digits of One Hand												X		X	X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5127	Amputation of thumb, index, middle and ring fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5131	Amputation of index, middle, ring and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5132	Amputation of thumb, index, middle fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5133	Amputation of thumb, index, and ring fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5137	Amputation of thumb, ring and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5138	Amputation of index, middle and ring fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5139	Amputation of index, middle and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5141	Amputation of middle, ring and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5142	Amputation of thumb and index fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5146	Amputation of index and middle fingers												X		X	X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5147	Amputation of index and ring fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5148	Amputation of index and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5149	Amputation of middle and ring fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5150	Amputation of middle and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5151	Amputation of ring and little fingers												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5152	Amputation of thumb												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5153	Amputation of index finger												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5154	Amputation of middle finger												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5155	Amputation of ring finger												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5156	Amputation of little finger												X		X	X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5160	Amputation of thigh, Disarticulation of hip with loss of extrinsic pelvic girdle muscles														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5161	Amputation of thigh through upper third of femur														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5162	Amputation of thigh through middle or lower third of femur														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5163	Amputation of Leg with Defective Stump														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5164	Amputation of Leg not improvable by prosthesis controlled by natural knee action														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5165	Amputation of Leg at a lower level permitting prosthesis														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5166	Forefoot, Amputation Proximal to Metatarsal Bones												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5167	Foot, Loss of Use of												X		X	X	X	X	

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5170	Amputation of all toes without metatarsal loss												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5171	Amputation of great toe without metatarsal loss												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5172	Amputation of toes other than great toe without metatarsal loss												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5173	Amputation of three or four toes without metatarsal involvement												X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5199	Generalized, Combinations of Disabilities and Amputations of the Musculoskeletal System										X	X	X		X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5200	Scapulohumeral Articulation, Ankylosis of														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5201	Limitation of motion of arm										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5202	Other Impairment of Humerus														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5203	Impairment of clavicle or scapula														X	X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5205	Elbow, Ankylosis of														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5206	Limitation of flexion of forearm										X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5207	Limitation of extension of forearm										X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5208	Forearm, flexion limited to 100 degrees and extension to 45 degrees														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5209	Elbow, other impairment of Flail joint										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5210	Radius and Ulna, Nonunion of, with Flail False Joint														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5211	Impairment of Ulna														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5212	Impairment of radius														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5213	Impairment of supination and pronation														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5214	Wrist, ankylosis														X	X	X	X	

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5215	Limitation of motion of the wrist										X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5216	Five digits of one hand, unfavorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5217	Four digits of one hand, unfavorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5218	Three digits of one hand, unfavorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5219	Two digits of one hand, unfavorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5220	Five digits of one hand, favorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5221	Four digits of one hand, favorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5222	Three digits of one hand, favorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5223	Two digits of one hand, favorable ankylosis of														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5224	Ankylosis of thumb														X	X	X	X	

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5225	Ankylosis of Index Finger														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5226	Ankylosis of Middle Finger														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5227	Ankylosis of any other finger														X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5250	Hip, ankylosis of										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5251	Thigh, Limitation of extension of										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5252	Thigh, Limitation of flexion of										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5253	Thigh, Impairment of										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5254	Hip, Flail joint														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5255	Femur, Impairment of														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5256	Knee, ankylosis of										X	X			X	X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5257	Other impairment of knee										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5258	Cartilage, semilunar, dislocated														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5259	Removal of semilunar cartilage, symptomatic																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5260	Limitation of flexion of leg										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5261	Limitation of extension of leg										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5262	Tibia and fibula, impairment of														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5263	Genu recurvatum														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5270	Ankle, ankylosis of										X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5271	Limited motion of the ankle										X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5272	Subastragalar or tarsal joint, ankylosis of										X	X			X	X	X	X	

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5273	Malunion of Os Calcis or Astragalus														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5274	Astragalectomy																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5275	Bones of the lower extremity, shortening of									X	X				X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5276	Flatfoot, acquired																X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5277	Weak foot, bilateral		X														X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5278	Claw foot (pes cavus), acquired																X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5279	Metatarsalgia, anterior (Morton's disease)																X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5280	Hallux valgus																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5281	Hallux rigidus																		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5282	Hammer toe																X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5283	Tarsal, or metatarsal bones, malunion of, or nonunion of														X		X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5284	Other foot injuries										X	X			X	X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5285	Vertebra, fracture of, residuals										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5286	Spine, complete bony fixation (ankylosis) of														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5287	Ankylosis of cervical spine										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5288	Ankylosis of dorsal spine										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5289	Ankylosis of lumbar spine										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5290	Limitation of motion of cervical spine										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5291	Limitation of motion of dorsal spine										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5292	Limitation of motion of lumbar spine										X	X			X	X	X		X

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5293	Intervertebral disc syndrome										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5294	Sacro-iliac injury and weakness														X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5295	Lumbo-sacral strain										X	X			X	X	X		X
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5296	Skull, loss of part of, both inner and outer tables														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5297	Ribs, removal of														X				
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5298	Coccyx, removal of														X				
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5299	Generalized, Elbow and Forearm, the Wrist, Multiple Fingers, Hip and Thigh, Knee and Leg, Ankle, Foot, the Spine, the Skull, the Ribs, the Coccyx										X	X			X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5301	Group I - Extrinsic Muscles of Shoulder Girdle															X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5302	Group II - Extrinsic Muscles of Shoulder Girdle															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5303	Group III - Intrinsic Muscles of Shoulder Girdle															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5304	Group IV - Intrinsic Muscles of Shoulder Girdle															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5305	Group V - Flexor muscles of the elbow															X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5306	Group VI - Extensor muscles of the elbow															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5307	Group VII - Muscles arising from INTERNAL condyle of humerus															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5308	Group VIII - Muscles arising mainly from external condyle of humerus															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5309	Group IX - Intrinsic muscles of hand															X	X	X	
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5310	Group X - Intrinsic muscles of the foot															X	X	X	

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5311	Group XI - Posterior and lateral crural muscles, Muscles of the calf															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5312	Group XII - Anterior muscles of the leg															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5313	Group XIII - Posterior thigh group															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5314	Group XIV - Anterior thigh group															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5315	Group XV - Mesial thigh group															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5316	Group XVI - Pelvic girdle group 1															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5317	Group XVII - Pelvic girdle group 2															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5318	Group XVIII - Pelvic girdle group 3															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5319	Group XIX - Muscles of abdominal wall															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5320	Group XX - Spinal muscles															X	X		

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5321	Group XXI - Muscles of respiration															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5322	Group XXII - Lateral, suprA, and infra-hyoid group															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5323	Group XXIII - Lateral and posterior muscles of the neck															X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5324	Rupture of diaphragm with herniation														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5325	Facial muscle injury														X	X	X		
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5326	Muscle hernia, extensive, without other injury to muscle														X				
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5327	Muscle, New Growth of, Malignant							X											
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5328	Muscle, New growth of, benign, post-operative							X											
50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5329	Soft tissue sarcoma							X											

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50	Bones and Joints Disease	5000-5399	Musculoskeletal System	5399	Generalized, Shoulder and Girdle Muscles, the Forearm and Hand, the Foot and Leg, the Pelvic Girdle and Thigh, the Torso and Neck										X	X			X	X	X	X	
60	Eye and Visual Acuity	6000-6099	Eye	6000	Uveitis		X						X	X				X					
60	Eye and Visual Acuity	6000-6099	Eye	6001	Keratitis		X						X	X				X					
60	Eye and Visual Acuity	6000-6099	Eye	6002	Scleritis		X						X	X				X					
60	Eye and Visual Acuity	6000-6099	Eye	6003	Iritis		X						X	X									
60	Eye and Visual Acuity	6000-6099	Eye	6004	Cyclitis		X						X	X									
60	Eye and Visual Acuity	6000-6099	Eye	6005	Choroiditis		X						X	X									
60	Eye and Visual Acuity	6000-6099	Eye	6006	Retinitis		X						X										
60	Eye and Visual Acuity	6000-6099	Eye	6007	Hemorrhage, intra-ocular, recent								X		X	X							

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60	Eye and Visual Acuity	6000-6099	Eye	6008	Retina, detachment of					X					X	X			X		X		
60	Eye and Visual Acuity	6000-6099	Eye	6009	Eye, injury of, unhealed					X			X	X				X	X	X	X		
60	Eye and Visual Acuity	6000-6099	Eye	6010	Eye, tuberculosis of, active or inactive																		
60	Eye and Visual Acuity	6000-6099	Eye	6011	Retina, localized scars								X										
60	Eye and Visual Acuity	6000-6099	Eye	6012	Glaucoma, congestive or inflammatory		X																
60	Eye and Visual Acuity	6000-6099	Eye	6013	Glaucoma, simple, primary, non-congestive																		
60	Eye and Visual Acuity	6000-6099	Eye	6014	New Growths, malignant (eyeball only)							X											
60	Eye and Visual Acuity	6000-6099	Eye	6015	New Growths, benign (eyeball and adnexa, other than superficial)		X					X											
60	Eye and Visual Acuity	6000-6099	Eye	6016	Nystagmus, central																		
60	Eye and Visual Acuity	6000-6099	Eye	6017	Conjunctivitis, trachomatous, chronic																		

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60	Eye and Visual Acuity	6000-6099	Eye	6018	Conjunctivitis, other, chronic		X						X	X									
60	Eye and Visual Acuity	6000-6099	Eye	6019	Ptosis, unilateral or bilateral																		
60	Eye and Visual Acuity	6000-6099	Eye	6020	Ectropion																		
60	Eye and Visual Acuity	6000-6099	Eye	6021	Entropion																		
60	Eye and Visual Acuity	6000-6099	Eye	6022	Lagophthalmos																		
60	Eye and Visual Acuity	6000-6099	Eye	6023	Eyebrows, loss of, complete, unilateral or bilateral																		
60	Eye and Visual Acuity	6000-6099	Eye	6024	Eyelashes, loss of, complete, unilateral or bilateral																		
60	Eye and Visual Acuity	6000-6099	Eye	6025	Epiphora (lacrymal duct, interference with, from any cause)																		
60	Eye and Visual Acuity	6000-6099	Eye	6026	Neuritis, optic		X																
60	Eye and Visual Acuity	6000-6099	Eye	6027	Cataract, traumatic														X	X			

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60	Eye and Visual Acuity	6000-6099	Eye	6028	Cataract, senile, and others		X						X	X				X					
60	Eye and Visual Acuity	6000-6099	Eye	6029	Aphakia																		
60	Eye and Visual Acuity	6000-6099	Eye	6030	Accommodation, paralysis of		X																
60	Eye and Visual Acuity	6000-6099	Eye	6031	Dacryocystitis																		
60	Eye and Visual Acuity	6000-6099	Eye	6032	Eyelids, loss of portion of																X		
60	Eye and Visual Acuity	6000-6099	Eye	6033	Lens, crystalline, dislocation of		X								X	X			X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6034	Pterygium		X																
60	Eye and Visual Acuity	6000-6099	Eye	6035	Keratoconus																		
60	Eye and Visual Acuity	6000-6099	Eye	6061	Anatomical loss of both eyes														X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6062	Blindness both eyes having only light perception		X							X					X	X	X		

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60	Eye and Visual Acuity	6000-6099	Eye	6063	Anatomical loss of one eye and defective visual acuity other eye														X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6064	Anatomical loss of one eye and defective visual acuity other eye														X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6065	Anatomical loss of one eye and defective visual acuity other eye														X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6066	Anatomical loss of one eye and defective visual acuity other eye														X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6067	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6068	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6069	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6070	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6071	Defective visual acuity		X				X		X	X					X	X			

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60	Eye and Visual Acuity	6000-6099	Eye	6072	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6073	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6074	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6075	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6076	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6077	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6078	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6079	Defective visual acuity		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6080	Impairment of Field vision		X				X		X	X					X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6081	Scotoma, pathological, unilateral								X										

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60	Eye and Visual Acuity	6000-6099	Eye	6090	Impairment of muscle function (Eye)		X												X	X			
60	Eye and Visual Acuity	6000-6099	Eye	6091	Symblepharon		X																
60	Eye and Visual Acuity	6000-6099	Eye	6092	Diplopia, due to limited muscle function														X	X	X		
60	Eye and Visual Acuity	6000-6099	Eye	6099	Generalized, Disease of the Eye, Impairment of Central Visual Acuity, Impairment of Field of Vision, Impairment of Muscle Function (eyes)		X				X			X									
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6100	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6101	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6102	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6103	Defective hearing		X	X		X	X												

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61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6104	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6105	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6106	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6107	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6108	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6110	Defective hearing		X	X		X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6199	Generalized, Hearing Impairment		X	X	X	X	X												
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6200	Otitis media, suppurative, chronic																		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6201	Otitis media, catarrhal, chronic																		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6202	Otosclerosis		X		X														

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61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6203	Otitis interna																		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6204	Labyrinthitis, chronic		X		X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6205	Meniere's Syndrome		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6206	Mastoiditis																		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6207	Auricle, loss of or deformity												X		X	X	X		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6208	New Growths, malignant ear, other than of skin only							X											
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6209	New Growths, benign, ear, other than of skin only							X											
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6210	Auditory canal, disease of																		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6211	Tympanic membrane, perforation of			X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6260	Tinnitus		X	X	X	X													

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61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6275	Smell, Loss of sense of, complete		X														X		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6276	Taste, Loss of sense of, complete		X														X		
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6280	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6282	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6284	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6285	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6290	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6291	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6293	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6295	Hearing loss		X	X	X	X													

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61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6296	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6297	Hearing loss		X	X	X	X													
61 & 62	Ear, Smell, & Taste	6100-6299	Impairment of Auditory Acuity	6299	Generalized, Diseases of the Ear		X	X	X	X													
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6301	Kala-azar (visceral leishmaniasis)																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6302	Leprosy (Hansen's Disease)																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6304	Malaria																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6305	Filariasis																		

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63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6306	Oroya fever																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6308	Relapsing fever																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6309	Rheumatic fever																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6310	Syphilis, unspecified																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6311	Tuberculosis, military																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6313	Avitaminosis																		

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63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6314	Beriberi																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6315	Pellagra																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6316	Brucellosis (Malta or undulant fever)																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6317	Typhus, scrub																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6318	Melioidosis																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6319	Lyme Disease																		

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63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6320	Parasitic diseases otherwise not specified																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6350	Lupus erythematosus, systemic																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6351	HIV-Related illness																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6352	AIDS related complex																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6353	HIV infection																		
63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6354	Chronic Fatigue Syndrome (CFS)	X	X																

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63	Systemic Disease	6300-6399	Infectious Disease, Immune Disorders, Nutritional Deficiencies	6399	Generalized, Infectious Diseases, Immune Disorder and Nutritional Deficiencies																		
65	Nose & Throat	6501-6899	Respiratory System	6501	Rhinitis, atrophic, chronic		X																
65	Nose & Throat	6501-6899	Respiratory System	6502	Septum, nasal, deflection of																		
65	Nose & Throat	6501-6899	Respiratory System	6504	Nose, loss of part of, or scars		X									X			X	X	X		
65	Nose & Throat	6501-6899	Respiratory System	6510	Sinusitis, paranasal, chronic		X												X	X			
65	Nose & Throat	6501-6899	Respiratory System	6511	Sinusitis, ethmoid, chronic		X												X	X			
65	Nose & Throat	6501-6899	Respiratory System	6512	Sinusitis, frontal, chronic		X												X	X			
65	Nose & Throat	6501-6899	Respiratory System	6513	Sinusitis, maxillary, chronic		X												X	X			
65	Nose & Throat	6501-6899	Respiratory System	6514	Sinusitis, sphenoid, chronic		X												X	X			
65	Nose & Throat	6501-6899	Respiratory System	6515	Laryngitis, tuberculous, active or inactive																		
65	Nose & Throat	6501-6899	Respiratory System	6516	Laryngitis, chronic																		
65	Nose & Throat	6501-6899	Respiratory System	6517	Larynx, injuries of, healed																		

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65	Nose & Throat	6501-6899	Respiratory System	6518	Laryngectomy																		
65	Nose & Throat	6501-6899	Respiratory System	6519	Aphonia, organic																		
65	Nose & Throat	6501-6899	Respiratory System	6520	Larynx, stenosis of														X	X	X		
65	Nose & Throat	6501-6899	Respiratory System	6521	Pharynx, injuries to														X	X			
65	Nose & Throat	6501-6899	Respiratory System	6522	Allergic or vasomotor rhinitis		X																
65	Nose & Throat	6501-6899	Respiratory System	6523	Bacterial rhinitis																		
65	Nose & Throat	6501-6899	Respiratory System	6524	Granulomatous rhinitis																		
65	Nose & Throat	6501-6899	Respiratory System	6599	Generalized, Disease of the Nose and Throat		X																
66	Trachea & Bronchi	6501-6899	Respiratory System	6600	Bronchitis, chronic		X																
66	Trachea & Bronchi	6501-6899	Respiratory System	6601	Bronchiectasis		X																
66	Trachea & Bronchi	6501-6899	Respiratory System	6602	Asthma, bronchial		X																
66	Trachea & Bronchi	6501-6899	Respiratory System	6603	Emphysema, pulmonary		X																
66	Trachea & Bronchi	6501-6899	Respiratory System	6604	Chronic obstructive pulmonary disease		X																
66	Trachea & Bronchi	6501-6899	Respiratory System	6699	Generalized, Diseases of the Trachea and Bronchi		X												X	X			

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67	TB, Lungs & Pleura	6501-6899	Respiratory System	6702	Tuberculosis, pulmonary, chronic, moderately advanced, active	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6704	Tuberculosis, pulmonary, chronic, active, advancement not specified	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6722	Tuberculosis, pulmonary, chronic, moderately advanced, inactive	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6723	Tuberculosis, pulmonary, chronic, minimal, inactive	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6724	Tuberculosis, pulmonary, chronic, inactive, advancement unspecified	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6730	Tuberculosis, pulmonary, chronic, active	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6731	Tuberculosis, pulmonary, chronic, inactive	X	X																

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67	TB, Lungs & Pleura	6501-6899	Respiratory System	6732	Pleurisy, tuberculous, active or inactive	X	X																
67	TB, Lungs & Pleura	6501-6899	Respiratory System	6799	Generalized, Diseases of the Lungs and Pleura - - Tuberculosis	X	X												X	X			
68	Non-TB Diseases	6501-6899	Respiratory System	6800	Anthracosis (Black Lung Disease)		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6801	Silicosis	X	X																
68	Non-TB Diseases	6501-6899	Respiratory System	6802	Pneumoconiosis, unspecified		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6803	Actinomycosis of the lung																		
68	Non-TB Diseases	6501-6899	Respiratory System	6805	Blastomycosis of lung																		
68	Non-TB Diseases	6501-6899	Respiratory System	6806	Sporotrichosis of lung																		
68	Non-TB Diseases	6501-6899	Respiratory System	6807	Aspergillosis of lung																		
68	Non-TB Diseases	6501-6899	Respiratory System	6808	Mycosis of lung, unspecified																		
68	Non-TB Diseases	6501-6899	Respiratory System	6809	Lung, abscess of																		
68	Non-TB Diseases	6501-6899	Respiratory System	6810	Pleurisy, serofibrinous		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6811	Pleurisy, purulent (empyema)		X																

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68	Non-TB Diseases	6501-6899	Respiratory System	6812	Fistula, bronchocutaneous, or bronchopleural																		
68	Non-TB Diseases	6501-6899	Respiratory System	6813	Lung, permanent collapse of																		
68	Non-TB Diseases	6501-6899	Respiratory System	6814	Pneumothorax, spontaneous																		
68	Non-TB Diseases	6501-6899	Respiratory System	6815	Pneumectomy																		
68	Non-TB Diseases	6501-6899	Respiratory System	6816	Lobectomy																		
68	Non-TB Diseases	6501-6899	Respiratory System	6817	Lung chronic passive congestion of		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6818	Pleural cavity, injuries, residuals of, including gunshot wounds																		
68	Non-TB Diseases	6501-6899	Respiratory System	6819	New growths, malignant, any specified part of the respiratory system exclusive of skin growths		X					X											
68	Non-TB Diseases	6501-6899	Respiratory System	6820	New growths of, benign, any specified part of respiratory system		X					X											
68	Non-TB Diseases	6501-6899	Respiratory System	6821	Coccidioidomycosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6822	Actinomycosis																		

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68	Non-TB Diseases	6501-6899	Respiratory System	6824	Chronic lung abscess																		
68	Non-TB Diseases	6501-6899	Respiratory System	6825	Diffuse interstitial fibrosis (interstitial pneumonitis, fibrosing alveolitis)		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6826	Desquamative interstitial pneumonitis		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6827	Pulmonary alveolar proteinosis		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6828	Eosinophili granuloma of lung		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6829	Drug-induced pulmonary pneumonitis and fibrosis		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6830	Radiation-induced pulmonary pneumonitis and fibrosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6831	Hypersensitivity pneumonitis (extrinsic allergic alveolitis)		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6832	Pneumoconiosis (silicosis, anthracosis, etc.)		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6833	Asbestosis		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6834	Histoplasmosis of lung																		

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68	Non-TB Diseases	6501-6899	Respiratory System	6835	Coccidioidomycosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6836	Blastomycosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6837	Cryptococcosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6838	Aspergillosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6839	Aspergillosis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6840	Diaphragm paralysis or paresis																		
68	Non-TB Diseases	6501-6899	Respiratory System	6841	Spinal cord injury with respiratory insufficiency										X	X							
68	Non-TB Diseases	6501-6899	Respiratory System	6842	Kyphoscoliosis, pectus excavatum, pectus carinatum																		
68	Non-TB Diseases	6501-6899	Respiratory System	6843	Traumatic chest wall defect, pneumothorax, hernia, etc.																		
68	Non-TB Diseases	6501-6899	Respiratory System	6844	Post-surgical residual (lobectomy, pneumonectomy, etc.)																		
68	Non-TB Diseases	6501-6899	Respiratory System	6845	Chronic pleural effusion or fibrosis		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6846	Sarcoidosis																		

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68	Non-TB Diseases	6501-6899	Respiratory System	6847	Sleep Apnea Syndromes (Obstructive, Central, Mixed)		X																
68	Non-TB Diseases	6501-6899	Respiratory System	6899	Generalized, Nontuberculous Diseases		X																
70	Heart Diseases	7000-7199	Cardiovascular System	7000	Rheumatic Heart Disease																		
70	Heart Diseases	7000-7199	Cardiovascular System	7001	Endocarditis		X																
70	Heart Diseases	7000-7199	Cardiovascular System	7002	Pericarditis		X																
70	Heart Diseases	7000-7199	Cardiovascular System	7003	Adhesions, Pericardial		X																
70	Heart Diseases	7000-7199	Cardiovascular System	7004	Syphilitic heart disease																		
70	Heart Diseases	7000-7199	Cardiovascular System	7005	Arteriosclerotic Heart Disease		X																
70	Heart Diseases	7000-7199	Cardiovascular System	7006	Myocardium, infarction of, due to thrombosis or embolism		X												X	X			
70	Heart Diseases	7000-7199	Cardiovascular System	7007	Hypertensive heart disease		X	X	X														
70	Heart Diseases	7000-7199	Cardiovascular System	7008	Hyperthyroid heart disease																		
70	Heart Diseases	7000-7199	Cardiovascular System	7010	Auricular flutter, paroxysmal			X	X														
70	Heart Diseases	7000-7199	Cardiovascular System	7011	Auricular fibrillation (Sustained)																		

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70	Heart Diseases	7000-7199	Cardiovascular System	7012	Auricular fibrillation, permanent																		
70	Heart Diseases	7000-7199	Cardiovascular System	7013	Tachycardia, paroxysmal		X	X	X		X						X	X	X	X		X	X
70	Heart Diseases	7000-7199	Cardiovascular System	7014	Sinus tachycardia		X	X	X		X						X	X	X	X		X	X
70	Heart Diseases	7000-7199	Cardiovascular System	7015	Auriculoventricular Block		X				X						X	X	X	X			
70	Heart Diseases	7000-7199	Cardiovascular System	7016	Heart Valve Replacement																		
70	Heart Diseases	7000-7199	Cardiovascular System	7017	Coronary Artery Bypass Surgery																		
70	Heart Diseases	7000-7199	Cardiovascular System	7018	Implantable cardiac pacemakers																		
70	Heart Diseases	7000-7199	Cardiovascular System	7019	Cardiac transplantation																		
70	Heart Diseases	7000-7199	Cardiovascular System	7020	Cardiomyopathy		X																
70	Heart Diseases	7000-7199	Cardiovascular System	7099	Generalized, Diseases of the Heart		X	X	X		X							X	X	X	X		
71	Arteries & Veins	7000-7199	Cardiovascular System	7100	Arteriosclerosis, general																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7101	Hypertensive vascular disease (essential arterial hypertension)																		

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71	Arteries & Veins	7000-7199	Cardiovascular System	7110	Aneurysm, aortic, fusiform, saccular, dissection and/or stenosis																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7111	Artery, any large, aneurysm of																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7112	Artery, small, aneurysmal dilatation of																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7113	Arteriovenous Aneurysm, Traumatic																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7114	Arteriosclerosis Obliterans																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7115	Thromboangiitis Obliterans (buerger's disease)																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7116	Claudication, intermittent						X						X						
71	Arteries & Veins	7000-7199	Cardiovascular System	7117	Raynaud's disease		X										X				X	X	
71	Arteries & Veins	7000-7199	Cardiovascular System	7118	Angioneurotic edema		X																
71	Arteries & Veins	7000-7199	Cardiovascular System	7119	Erythromelalgia																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7120	Varicose Veins																	X	

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71	Arteries & Veins	7000-7199	Cardiovascular System	7121	Phlebitis or Thrombophlebitis, unilateral, with obliteration of deep return circulation, including traumatic conditions																		
71	Arteries & Veins	7000-7199	Cardiovascular System	7122	Frozen Feet, Residuals of (immersion foot)												X						
71	Arteries & Veins	7000-7199	Cardiovascular System	7123	Soft-tissue sarcoma (of vascular origin)							X											
71	Arteries & Veins	7000-7199	Cardiovascular System	7199	Generalized, Diseases of the Arteries and Veins																		
72 & 73	Digestive System	7200-7399	Digestive System	7200	Mouth, injuries of														X	X			
72 & 73	Digestive System	7200-7399	Digestive System	7201	Lips, injuries of												X		X	X	X		
72 & 73	Digestive System	7200-7399	Digestive System	7202	Tongue, loss of whole or part														X	X	X		
72 & 73	Digestive System	7200-7399	Digestive System	7203	Esophageal Stricture		X																
72 & 73	Digestive System	7200-7399	Digestive System	7204	Esophageal Spasm		X																
72 & 73	Digestive System	7200-7399	Digestive System	7205	Esophageal diverticulum, acquired																		
72 & 73	Digestive System	7200-7399	Digestive System	7299	Generalized, Digestive System		X					X											

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72 & 73	Digestive System	7200-7399	Digestive System	7301	Peritoneum, adhesions		X												X	X			
72 & 73	Digestive System	7200-7399	Digestive System	7304	Gastric ulcer		X																X
72 & 73	Digestive System	7200-7399	Digestive System	7305	Duodenal ulcer		X																X
72 & 73	Digestive System	7200-7399	Digestive System	7306	Ulcer, marginal (gastrojejunal)		X																
72 & 73	Digestive System	7200-7399	Digestive System	7307	Gastritis, hypertrophic		X	X	X														
72 & 73	Digestive System	7200-7399	Digestive System	7308	Postgastrectomy syndromes																		
72 & 73	Digestive System	7200-7399	Digestive System	7309	Stomach stenosis		X																
72 & 73	Digestive System	7200-7399	Digestive System	7310	Stomach, injury of, residuals					X									X	X			X
72 & 73	Digestive System	7200-7399	Digestive System	7311	Liver injury		X			X									X	X			
72 & 73	Digestive System	7200-7399	Digestive System	7312	Liver, cirrhosis		X																
72 & 73	Digestive System	7200-7399	Digestive System	7313	Liver abscess, residuals of																		
72 & 73	Digestive System	7200-7399	Digestive System	7314	Cholecystitis, chronic		X																
72 & 73	Digestive System	7200-7399	Digestive System	7315	Cholelithiasis, chronic		X																
72 & 73	Digestive System	7200-7399	Digestive System	7316	Cholangitis, chronic		X																
72 & 73	Digestive System	7200-7399	Digestive System	7317	Gall bladder injury					X										X			

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72 & 73	Digestive System	7200-7399	Digestive System	7318	Gall bladder, removal of																		
72 & 73	Digestive System	7200-7399	Digestive System	7319	Irritable colon		X																X
72 & 73	Digestive System	7200-7399	Digestive System	7321	Amebiasis																		
72 & 73	Digestive System	7200-7399	Digestive System	7322	Dysentery, bacillary																		
72 & 73	Digestive System	7200-7399	Digestive System	7323	Ulcerative colitis																		
72 & 73	Digestive System	7200-7399	Digestive System	7324	Distomiasis, intestinal or hepatic																		
72 & 73	Digestive System	7200-7399	Digestive System	7325	Enteritis, chronic																		
72 & 73	Digestive System	7200-7399	Digestive System	7326	Enterocolitis, chronic																		
72 & 73	Digestive System	7200-7399	Digestive System	7327	Diverticulitis																		
72 & 73	Digestive System	7200-7399	Digestive System	7328	Intestine, small, resection of																		
72 & 73	Digestive System	7200-7399	Digestive System	7329	Intestine, large, resection of																		
72 & 73	Digestive System	7200-7399	Digestive System	7330	Intestine, fistula of																		
72 & 73	Digestive System	7200-7399	Digestive System	7331	Peritonitis, tuberculous																		
72 & 73	Digestive System	7200-7399	Digestive System	7332	Rectum and anus, impairment of sphincter control																		
72 & 73	Digestive System	7200-7399	Digestive System	7333	Rectum and anus, stricture of																		

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72 & 73	Digestive System	7200-7399	Digestive System	7334	Rectum, persistent prolapsed																		
72 & 73	Digestive System	7200-7399	Digestive System	7335	Ano, Fistula in																		
72 & 73	Digestive System	7200-7399	Digestive System	7336	Hemorrhoids, external or internal																		X
72 & 73	Digestive System	7200-7399	Digestive System	7337	Pruritus ani																		
72 & 73	Digestive System	7200-7399	Digestive System	7338	Hernia, inguinal																		
72 & 73	Digestive System	7200-7399	Digestive System	7339	Hernia, ventral, postoperative																		
72 & 73	Digestive System	7200-7399	Digestive System	7340	Hernia, femoral																		
72 & 73	Digestive System	7200-7399	Digestive System	7342	Visceroptosis, Symptomatic, Marked																		
72 & 73	Digestive System	7200-7399	Digestive System	7343	New growths, malignant, exclusive of skin growths							X											
72 & 73	Digestive System	7200-7399	Digestive System	7344	New growths, benign, any part of digestive system, exclusive of skin growths							X											
72 & 73	Digestive System	7200-7399	Digestive System	7345	Hepatitis, infectious																		
72 & 73	Digestive System	7200-7399	Digestive System	7346	Hernia, hiatal																		

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72 & 73	Digestive System	7200-7399	Digestive System	7347	Pancreatitis		X																
72 & 73	Digestive System	7200-7399	Digestive System	7348	Vagotomy with pyloroplasty or gastroenterostomy																		
72 & 73	Digestive System	7200-7399	Digestive System	7351	Liver Transplant																		
72 & 73	Digestive System	7200-7399	Digestive System	7354	Hepatitis C																		
72 & 73	Digestive System	7200-7399	Digestive System	7399	Generalized, Digestive System		X					X											
75	Genitourinary System	7500-7599	Genitourinary System	7500	Kidney, Removal of one, with nephritis, infection, or pathology of the other																		
75	Genitourinary System	7500-7599	Genitourinary System	7501	Kidney, abscess of																		
75	Genitourinary System	7500-7599	Genitourinary System	7502	Nephritis, chronic		X																
75	Genitourinary System	7500-7599	Genitourinary System	7504	Pyelonephritis, chronic																		
75	Genitourinary System	7500-7599	Genitourinary System	7505	Kidney, Tuberculosis of																		
75	Genitourinary System	7500-7599	Genitourinary System	7507	Nephrosclerosis, arteriolar																		

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75	Genitourinary System	7500-7599	Genitourinary System	7508	Nephrolithiasis																		
75	Genitourinary System	7500-7599	Genitourinary System	7509	Hydronephrosis																		
75	Genitourinary System	7500-7599	Genitourinary System	7510	Ureterolithiasis																		
75	Genitourinary System	7500-7599	Genitourinary System	7511	Ureter, stricture of																		
75	Genitourinary System	7500-7599	Genitourinary System	7512	Cystitis, chronic, includes interstitial and all etiologies, infectious and non-infectious																		
75	Genitourinary System	7500-7599	Genitourinary System	7513	Cystitis																		
75	Genitourinary System	7500-7599	Genitourinary System	7515	Bladder, calculus in, with symptoms interfering with function																		
75	Genitourinary System	7500-7599	Genitourinary System	7516	Bladder, Fistula of																		
75	Genitourinary System	7500-7599	Genitourinary System	7517	Bladder, injury of				X										X	X			

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75	Genitourinary System	7500-7599	Genitourinary System	7518	Urethra, stricture of																		
75	Genitourinary System	7500-7599	Genitourinary System	7519	Urethra, fistula of																		
75	Genitourinary System	7500-7599	Genitourinary System	7520	Penis, removal of half or more														X	X			
75	Genitourinary System	7500-7599	Genitourinary System	7521	Penis, removal of glans														X	X			
75	Genitourinary System	7500-7599	Genitourinary System	7522	Penis, deformity, with loss of erectile power														X	X			
75	Genitourinary System	7500-7599	Genitourinary System	7523	Testis, atrophy complete									X									
75	Genitourinary System	7500-7599	Genitourinary System	7524	Testis, removal														X	X			
75	Genitourinary System	7500-7599	Genitourinary System	7525	Epididymo-orchitis, chronic only																		
75	Genitourinary System	7500-7599	Genitourinary System	7526	Prostate gland resection																		
75	Genitourinary System	7500-7599	Genitourinary System	7527	Prostate gland injuries, infections, hypertrophy, post-operative residuals														X				

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75	Genitourinary System	7500-7599	Genitourinary System	7528	Malignant neoplasms of the genitourinary system							X											
75	Genitourinary System	7500-7599	Genitourinary System	7529	Benign neoplasms of the genitourinary system							X											
75	Genitourinary System	7500-7599	Genitourinary System	7530	Chronic renal disease requiring regular dialysis		X												X				
75	Genitourinary System	7500-7599	Genitourinary System	7531	Kidney transplant																		
75	Genitourinary System	7500-7599	Genitourinary System	7532	Renal tubular disorders		X			X								X					
75	Genitourinary System	7500-7599	Genitourinary System	7533	Cystic diseases of the kidneys																		
75	Genitourinary System	7500-7599	Genitourinary System	7534	Atherosclerotic renal disease																		
75	Genitourinary System	7500-7599	Genitourinary System	7535	Toxic nephropathy		X										X	X					
75	Genitourinary System	7500-7599	Genitourinary System	7536	Glomerulonephritis		X											X					
75	Genitourinary System	7500-7599	Genitourinary System	7537	Interstitial nephritis		X																

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75	Genitourinary System	7500-7599	Genitourinary System	7538	Papillary necrosis		X																
75	Genitourinary System	7500-7599	Genitourinary System	7539	Renal amyloid disease																		
75	Genitourinary System	7500-7599	Genitourinary System	7541	Renal involvement in diabetes, sickle cell anemia, systemic lupus erythematosus, vasculitis or other systemic disease processes																		
75	Genitourinary System	7500-7599	Genitourinary System	7542	Neurogenic Bladder														X				
75	Genitourinary System	7500-7599	Genitourinary System	7599	Generalized, Genitourinary System		X																
76	Gynecological	7610-7699	Gynecological Conditions	7610	Vulvovaginitis		X																
76	Gynecological	7610-7699	Gynecological Conditions	7611	Vaginitis																		
76	Gynecological	7610-7699	Gynecological Conditions	7612	Cervicitis																		
76	Gynecological	7610-7699	Gynecological Conditions	7613	Metritis																		
76	Gynecological	7610-7699	Gynecological Conditions	7614	Salpingitis																		
76	Gynecological	7610-7699	Gynecological Conditions	7615	Oophoritis																		

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76	Gynecological	7610-7699	Gynecological Conditions	7617	Uterus and Ovaries, Removal of, Complete																		
76	Gynecological	7610-7699	Gynecological Conditions	7618	Uterus removal of, including corpus																		
76	Gynecological	7610-7699	Gynecological Conditions	7619	Ovaries, removal of both																		
76	Gynecological	7610-7699	Gynecological Conditions	7620	Ovaries, complete atrophy of																		
76	Gynecological	7610-7699	Gynecological Conditions	7621	Uterus, Prolapse														X				
76	Gynecological	7610-7699	Gynecological Conditions	7622	Uterus, displacement of														X				
76	Gynecological	7610-7699	Gynecological Conditions	7623	Pregnancy, Surgical Complications of																		
76	Gynecological	7610-7699	Gynecological Conditions	7624	Fistula, Rectovaginal																		
76	Gynecological	7610-7699	Gynecological Conditions	7625	Fistula, urethrovaginal																		
76	Gynecological	7610-7699	Gynecological Conditions	7626	Mammary Glands, Removal of																		
76	Gynecological	7610-7699	Gynecological Conditions	7627	New Growth, Malignant, Gynecological System, or Mammary Glands																		
76	Gynecological	7610-7699	Gynecological Conditions	7628	Benign neoplasms of the gynecological system or breast.																		

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76	Gynecological	7610-7699	Gynecological Conditions	7629	Endometriosis																		
76	Gynecological	7610-7699	Gynecological Conditions	7699	Generalized, Gynecological Conditions and Disorders of the Breast		X										X						
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7700	Anemia, pernicious																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7701	Anemia, secondary		X					X											
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7702	Agranulocytosis, acute		X					X											
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7703	Leukemia		X					X											
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7704	Polycythemia, primary																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7705	Purpura hemorrhagica		X					X											
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7706	Splenectomy																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7707	Spleen, injury of, healed					X								X	X				

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77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7709	Lymphogranulomatosis (Hodgkin's Disease)																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7710	Adenitis, cervical, tuberculous, active or inactive																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7711	Adenitis, axillary, tuberculous, active or inactive																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7712	Adenitis, inguinal, tuberculous, active or inactive																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7713	Adenitis, secondary																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7714	Sickle Cell Anemia																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7715	Non-Hodgkin's Lymphoma																		
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7716	Aplastic anemia		X					X											
77	Hemic & Lymphatic	7700-7799	Hemic & Lymphatic Systems	7799	Generalized, Hemic and Lymphatic Systems		X					X										X	
78	Skin	7800-7899	Skin	7800	Scars, disfiguring, head, face or neck	X	X					X	X	X				X	X	X			
78	Skin	7800-7899	Skin	7801	Scars, burns, third degree		X					X	X	X				X					

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78	Skin	7800-7899	Skin	7802	Scars, burns, second degree		X					X	X	X			X						
78	Skin	7800-7899	Skin	7803	Scars, superficial, poorly nourished												X						
78	Skin	7800-7899	Skin	7804	Scars, superficial, tender and painful		X					X	X	X			X	X	X				
78	Skin	7800-7899	Skin	7805	Scars, other	X	X					X	X	X			X	X	X	X	X		
78	Skin	7800-7899	Skin	7806	Eczema	X	X																
78	Skin	7800-7899	Skin	7807	Leishmaniasis, Americana (mucocutaneous)																		
78	Skin	7800-7899	Skin	7808	Leishmaniasis, old world (cutaneous, oriental sore)																		
78	Skin	7800-7899	Skin	7809	Lupus erythematosus, discoid																		
78	Skin	7800-7899	Skin	7810	Pinta																		
78	Skin	7800-7899	Skin	7812	Verruga Peruana																		
78	Skin	7800-7899	Skin	7813	Dermatophytosis																		
78	Skin	7800-7899	Skin	7814	Tinea Barbae																		
78	Skin	7800-7899	Skin	7815	Pemphigus																		
78	Skin	7800-7899	Skin	7816	Psoriasis																		
78	Skin	7800-7899	Skin	7817	Dermatitis exfoliativa		X																
78	Skin	7800-7899	Skin	7818	New growths, malignant, skin		X					X											

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78	Skin	7800-7899	Skin	7819	New growths, benign, skin		X					X											
78	Skin	7800-7899	Skin	7899	Generalized, The Skin	X	X					X	X	X			X		X	X			
79	Endocrine System	7900-7999	Endocrine System	7900	Hyperthyroidism		X																
79	Endocrine System	7900-7999	Endocrine System	7901	Thyroid gland, toxic adenoma of		X					X											
79	Endocrine System	7900-7999	Endocrine System	7902	Thyroid gland, non-toxic adenoma of							X											
79	Endocrine System	7900-7999	Endocrine System	7903	Hypothyroidism		X					X											
79	Endocrine System	7900-7999	Endocrine System	7904	Hyperparathyroidism (osteitis fibrosa cystica)		X																
79	Endocrine System	7900-7999	Endocrine System	7905	Hypoparathyroidism		X																
79	Endocrine System	7900-7999	Endocrine System	7907	Hyperpituitarism (pituitary basophilism, Cushing's syndrome)		X																
79	Endocrine System	7900-7999	Endocrine System	7908	Hyperpituitarism (acromegaly or gigantism)		X																
79	Endocrine System	7900-7999	Endocrine System	7909	Hypopituitarism (diabetes insipidus)		X																
79	Endocrine System	7900-7999	Endocrine System	7910	Hyperadrenia (adrenogenital syndrome)		X																

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79	Endocrine System	7900-7999	Endocrine System	7911	Addison's disease (adrenal cortical hypofunction)		X																
79	Endocrine System	7900-7999	Endocrine System	7912	Pluriglandular Syndromes																		
79	Endocrine System	7900-7999	Endocrine System	7913	Diabetes Mellitus		X																
79	Endocrine System	7900-7999	Endocrine System	7914	New growths, malignant, endocrine system		X					X											
79	Endocrine System	7900-7999	Endocrine System	7915	New Growths, Benign, Endocrine System		X					X											
79	Endocrine System	7900-7999	Endocrine System	7916	Hyperpituitarism (prolactin secreting pituitary dysfunction)		X																
79	Endocrine System	7900-7999	Endocrine System	7917	Hyperaldosteronism (benign or malignant)		X																
79	Endocrine System	7900-7999	Endocrine System	7918	Pheochromocytoma (benign or malignant)		X																
79	Endocrine System	7900-7999	Endocrine System	7919	C-cell hyperplasia of the thyroid																		
79	Endocrine System	7900-7999	Endocrine System	7999	Generalized, The Endocrine System		X																
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8000	Encephalitis, Epidemic, Chronic																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8002	Brain, new growths of, malignant							X											
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8003	Brain, new growths of, benign, minimum							X											
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8004	Paralysis Agitans																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8005	Bulbar Palsy																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8007	Brain, vessels, embolism of																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8008	Brain, vessels, thrombosis of																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8009	Brain, vessels, hemorrhage from														X	X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8010	Myelitis																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8011	Poliomyelitis, Anterior																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8012	Hematomyelia																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8013	Syphilis, Cerebrospinal																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8014	Syphilis, Meningovascular																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8015	Tabes dorsalis																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8017	Amyotrophic lateral sclerosis																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8018	Multiple sclerosis																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8019	Meningitis, cerebrospinal, epidemic																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8020	Brain, abscess of																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8021	New growths of the Spinal cord, Malignant																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8022	New growths of the Spinal cord, Benign																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8023	Progressive muscular atrophy		X												X	X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8024	Syringomyelia																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8025	Myasthenia gravis																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8045	Brain disease due to trauma					X					X	X			X	X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8046	Cerebral arteriosclerosis																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8099	Generalized, Organic Diseases of the Central Nervous System		X	X	X		X	X											
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8100	Migraine																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8103	Tic, Convulsive																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8104	Paramyoclonus multiplex (convulsive state, Myoclonic type)																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8105	Chorea, Sydenham's																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8106	Chorea, Huntington's																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8107	Athetosis, Acquired																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8108	Narcolepsy		X				X												
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8199	Generalized, Miscellaneous Diseases of the Central Nervouse System		X	X	X			X					X						
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8205	Fifth (trigeminal) cranial nerve, paralysis of														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8207	Seventh (Facial) cranial nerve, paralysis of														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8209	Ninth (Glossopharyngeal) cranial nerve, paralysis of														X	X			

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8210	Tenth (pneumogastric, Vagus) cranial nerve, paralysis of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8211	Eleventh (Spinal Accessory, external branch) cranial nerve, paralysis of														X	X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8212	Twelfth (Hypoglossal) cranial nerve, paralysis of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8299	Generalized, Diseases of the Cranial Nerves (Paralysis)		X										X		X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8305	Fifth (trigeminal) cranial nerve, neuritis of												X		X	X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8307	Seventh (Facial) cranial nerve, neuritis of												X		X	X			

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8309	Ninth (Glossopharyngeal) cranial nerve, neuritis of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8310	Tenth (pneumogastric, Vagus) cranial nerve, neuritis of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8311	Eleventh (Spinal Accessory, external branch) cranial nerve, neuritis of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8312	Twelfth (Hypoglossal) cranial nerve, neuritis of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8399	Generalized, Diseases of the Cranial Nerves (Neuritis)		X										X		X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8405	Fifth (trigeminal) cranial nerve, neuralgia of												X		X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8407	Seventh (Facial) cranial nerve, neuralgia of												X		X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8409	Ninth (Glossopharyngeal) cranial nerve, neuralgia of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8410	Tenth (pneumogastric, Vagus) cranial nerve, neuralgia OF															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8411	Eleventh (Spinal Accessory, external branch) cranial nerve, neuralgia of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8412	Twelfth (Hypoglossal) cranial nerve, neuralgia of															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8499	Generalized, Diseases of the Cranial Nerves (Neuralgia)														X	X			

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8510	paralysis of upper radicular group (fifth and Sixth cervicals)															X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8511	Paralysis of middle radicular group														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8512	Paralysis of lower radicular group														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8513	Paralysis of all radicular groups														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8514	Paralysis of the musculospiral nerve (radial nerve)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8515	Paralysis of the median nerve														X	X	X	X	

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8516	Paralysis of the ulnar nerve														X	X	X	X	
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8517	Paralysis of musculocutaneous nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8518	Paralysis of circumflex nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8519	Paralysis of long thoracic nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8520	Paralysis of sciatic nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8521	Paralysis of external popliteal nerve (common peroneal)														X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8522	Paralysis of musculocutaneous nerve (superficial peroneal)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8523	Paralysis of anterior tibial nerve (deep peroneal)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8524	Paralysis of interal popliteal nerve (tibial)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8525	Paralysis of posterior tibial nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8526	Paralysis of anterior crural nerve (femoral)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8527	Paralysis of internal saphenous nerve														X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8528	Paralysis of obturator nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8529	Paralysis of external cutaneous nerve of thigh														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8530	Paralysis of ilio-inguinal nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8540	Soft tissue sarcoma (neurogenic)														X	X			
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8599	Generalized, Diseases of the Peripheral Nerves (Paralysis)		X												X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8610	Neuritis of Upper Radicular group (fifth and sixth cervicals)																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8611	Neuritis of middle Radicular group																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8612	Neuritis of lower Radicular group																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8613	Neuritis of all Radicular groups																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8614	Neuritis of the musculospiral nerve (Radial nerve)																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8615	Neuritis of the median nerve																X	X	
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8616	Neuritis of the ulnar nerve																X	X	

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8617	Neuritis of musculocutaneous nerve																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8618	Neuritis of circumflex nerve																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8619	Neuritis of long thoracic nerve																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8620	Neuritis of sciatic nerve																X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8621	Neuritis of external popliteal nerve (common peroneal)																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8622	Neuritis of musculocutaneous nerve (superficial peroneal)																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8623	Neuritis of anterior tibial nerve (Deep peroneal)																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8624	Neuritis of internal popliteal nerve (tibial)																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8625	Neuritis of posterior tibial nerve																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8626	Neuritis of anterior crural nerve (femoral)																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8627	Neuritis of internal saphenous nerve																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8628	Neuritis of obturator nerve																		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8629	Neuritis of external cutaneous nerve of thigh																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8630	Neuritis of ilio-inguinal nerve of thigh																		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8699	Generalized, Diseases of the Peripheral Nerves (Neuritis)		X													X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8710	Neuralgia of upper radicular group (fifth and Sixth cervicals)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8711	Neuralgia of middle radicular group														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8712	Neuralgia of lower radicular group														X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8713	Neuralgia of all radicular groups														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8714	Neuralgia of the musculospiral nerve (radical nerve)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8715	Neuralgia of the median nerve														X	X	X	X	
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8716	Neuralgia of the ulnar nerve														X	X	X	X	
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8717	Neuralgia of musculocutaneous nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8718	Neuralgia of circumflex nerve														X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8719	Neuralgia of long thoracic nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8720	Neuralgia of sciatic nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8721	Neuralgia of external popliteal nerve (common peroneal)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8722	Neuralgia of musculocutaneous nerve (superficial peroneal)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8723	Neuralgia of anterior tibial nerve (deep peroneal)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8724	Neuralgia of internal popliteal nerve (tibial)														X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8725	Neuralgia of posterior tibial nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8726	Neuralgia of anterior crural nerve (femoral)														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8727	Neuralgia of internal saphenous nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8728	Neuralgia of obturator nerve														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8729	Neuralgia of external cutaneous nerve of thigh														X	X	X		
80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8730	Neuralgia of ilio-inguinal nerve														X	X	X		

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80 - 87	Organic Disease Central Nervous System	8000-8999	Neurological Conditions	8799	Generalized, Diseases of the Peripheral Nerves (Neuralgia)		X												X	X	X		
89	Epilepsies	8000-8999	Neurological Conditions	8910	Epilepsy, grand mal		X				X	X						X	X	X	X		
89	Epilepsies	8000-8999	Neurological Conditions	8911	Epilepsy, petit mal																		
89	Epilepsies	8000-8999	Neurological Conditions	8912	Epilepsy, Jacksonian type																		
89	Epilepsies	8000-8999	Neurological Conditions	8913	Epilepsy, diencephalic																		
89	Epilepsies	8000-8999	Neurological Conditions	8914	Epilepsy, psychomotor																		
89	Epilepsies	8000-8999	Neurological Conditions	8999	Generalized, The Epilepsies		X	X			X							X					
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9200	Dementia Praecox, simple type; Schizophrenia, simple type; Schizotypal personality disorder																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9201	Schizophrenia, Disorganized type																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9202	Schizophrenia, Catatonic type																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9203	Schizophrenia, Paranoid type																		

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90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9204	Schizophrenia, Undifferentiated type																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9205	Schizophrenia, Residual type; Schizoaffective disorder, other and unspecified types																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9206	Bipolar disorder, manic, depressed or mixed																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9207	Major depression with psychotic features																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9208	Paranoid disorders		X																
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9209	Major depression with melancholia																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9210	Atypical psychosis		X				X												
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9211	Schizoaffective disorder																		
90 & 92	Psychotic Disorders	9200-9599	Mental Disorders	9299	Generalized, Schizophrenia and Other Psychotic Disorders																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9300	Delirium associated with infection, trauma, circulatory disturbance, etc.																		

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91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9301	Dementia associated with central nervous system syphilis																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9302	Dementia associated with intracranial infections other than syphilis																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9303	Dementia associated with alcoholism		X																
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9304	Dementia associated with brain trauma																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9305	Multi-infarct dementia with cerebral arteriosclerosis																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9306	Multi-infarct dementia due to causes other than cerebral arteriosclerosis																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9307	Dementia associated with convulsive disorder (idiopathic epilepsy)		X																

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91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9308	Dementia associated with disturbances of metabolism		X				X												
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9309	Dementia associated with brain tumor																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9310	Dementia due to unknown cause		X												X	X	X		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9311	Dementia due to undiagnosed cause		X												X	X	X		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9312	Dementia, primary, degenerative																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9313	Psychosis associated with organic brain syndrome due to chronic alcoholic poisoning		X																
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9315	Dementia associated with epidemic encephalitis																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9322	Dementia associated with endocrine disorder																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9323	Dementia, Unknown		X				X												

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91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9324	Dementia associated with systemic infection																		
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9325	Dementia associated with drug or poison intoxication (other than alcohol)		X				X												
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9326	Dementia due to other neurologic or general medical conditions (endocrine disorders, metabolic disorders, Pick's disease, brain tumors, etc.) or that are substance-induced (drugs, alcohol, poisons)		X				X												
91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9327	Organic mental disorder, other (including personality change due to a general medical condition)							X											

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91 & 93	Organic Brain Disorders	9200-9599	Mental Disorders	9399	Generalized, Delirium, Dementia, and Amnestic and Other Cognitive Disorders		X				X												
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9400	Generalized anxiety disorder		X	X	X		X												
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9401	Psychogenic amnesia, Psychogenic fugue; Multiple personality		X																
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9402	Conversion disorder; Psychogenic pain disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9403	Phobic disorder			X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9404	Obsessive compulsive disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9405	Dysthymic disorder; Adjustment disorder with depressed mood, Major depression without melancholia																		

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94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9408	Depersonalization disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9409	Hypochondriasis																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9410	Other and unspecified neurosis		X																
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9411	Post-Traumatic Stress Disorder		X			X							X	X	X	X	X	X	
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9412	Panic disorder and/or agoraphobia						X												
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9413	Anxiety disorder, not otherwise specified		X				X												
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9416	Dissociative amnesia; dissociative fugue; dissociative identity disorder (multiple personality disorder)		X																
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9417	Depersonalization disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9421	Somatization disorder			X	X										X	X	X		

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94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9422	Pain disorder		X	X	X										X	X	X		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9423	Undifferentiated somatoform disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9424	Conversion disorder		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9425	Hypochondriasis		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9431	Cyclothymic disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9432	Bipolar disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9433	Dysthymic disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9434	Major depressive disorder																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9435	Mood disorder, not otherwise specified																		
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9440	Chronic adjustment disorder			X	X														

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94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9499	Generalized, Anxiety Disorders, Dissociative Disorders, Somatoform Disorders, Mood Disorders		X	X	X		X												
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9500	Psychological factors affecting skin condition		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9501	Psychological factors affecting cardiovascular condition		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9502	Psychological factors affecting gastrointestinal condition		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9505	Psychological factors affecting musculoskeletal condition		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9506	Psychological factors affecting respiratory condition		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9508	Psychological factors affecting genitourinary condition		X	X	X														

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94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9510	Psychological factors affecting condition of organ of special sense		X	X	X														
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9511	Psychological factors affecting other type of physical condition		X	X	X		X												
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9520	Anorexia nervosa		X																
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9521	Bulimia nervosa		X																
94 & 95	Psychoneurological Disorders	9200-9599	Mental Disorders	9599	Generalized, Eating Disorders		X	X	X														
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9900	Maxilla or mandible, chronic osteomyelitis or osteoradionecrosis														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9901	Mandible, Loss of, complete, between angles														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9902	Mandible, Loss of approximately one-half														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9903	Mandible, nonunion of														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9904	Mandible, malunion of														X	X	X		

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Major Diagnostic Code	Major Diagnosis Code	Diagnostic Code Range	Body System	Diagnostic Code	Diagnosis	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9905	Temporomandibular articulation, limited motion of														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9906	Ramus, Loss of whole or part of														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9907	Ramus, Loss of less than one-half the substance of, not involving loss of continuity														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9908	Condylod process, Loss of, one or both sides														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9909	Coronoid process, Loss of														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9910	Loss of mandible														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9911	Hard palate, Loss of half or more															X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9912	Hard palate, Loss of less than half of															X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9913	Teeth, loss of, due to loss of substance of body of maxilla or mandible		X												X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9914	Maxilla, Loss of more than half														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9915	Maxilla, Loss of half or less														X	X	X		
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9916	Maxilla, malunion or nonunion														X	X	X		

Major Diagnostic Code	Major Diagnosis Code	Diagnostic Code Range	Body System	Diagnostic Code	Diagnosis	Biological substances	Chemical Substances	Impulse Noise	Steady State Noise	Blast Overpressure	Oxygen Deficiency	Ionizing radiation	Laser Radiation	Microwave radiation	Acceleration Shock	Deceleration Shock	Cold temperature Extremes	Heat temperature Extremes	Blunt Trauma	Sharp Trauma	Musculoskeletal Trauma	Segmental Vibration	Whole Body Vibration
99	Dental and Oral	9900-9999	Dental and Oral Conditions	9999	Generalized, Dental and Oral Conditions		X												X	X	X		

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

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7-1. CONCLUSIONS FOR MILITARY INJURY PREVENTION

A. AN EVIDENCE-BASED APPROACH TO INJURY PREVENTION.

(1) Adoption of an evidence-based approach to prevention, as described in Chapter 1, offers the Services and Department of Defense an opportunity to not only significantly reduce the incidence of injuries to Service members but also to establish a model for safety and public health practice for military and civilian communities.

(2) The chapters in this report described—

(A) How priorities can be set using military surveillance and research data (Chapter 2),

(B) Use of medical surveillance data can be used to identify and monitor military injury problems (Chapter 3),

(C) Use of mishap (safety) report data to describe details necessary for targeting prevention efforts,

(D) How systematic reviews can be employed to provide military-relevant information on what works to prevent injuries (Chapter 5),

(E) Results of selected military injury prevention program evaluations and research (Chapter 5), and

(F) A method for calculating costs associated with military injuries (Chapter 6).

B. LESSONS LEARNED FROM EPIDEMIOLOGIC ANALYSES (CHAPTER 3).

(1) Medical surveillance data show that injuries are the largest medical problem for the Services. In 2006, acute and chronic injuries accounted for 1.14 million outpatient encounters and 12,000 hospitalizations (Figure 7-1-1).

(2) With approximately 1,500 outpatient visits and 16 hospitalizations for every 1 death (Figure 7-1-1), deaths are a small piece of the military injury problem.

(3) Causes of injury differ by level of severity. Motor vehicle accidents are the predominant reason for injury deaths. Motor vehicle accidents, falls, and sports are the leading causes of injury hospitalizations. Physical training and sports have been shown to be the leading reasons for outpatient visits when cause information is available.

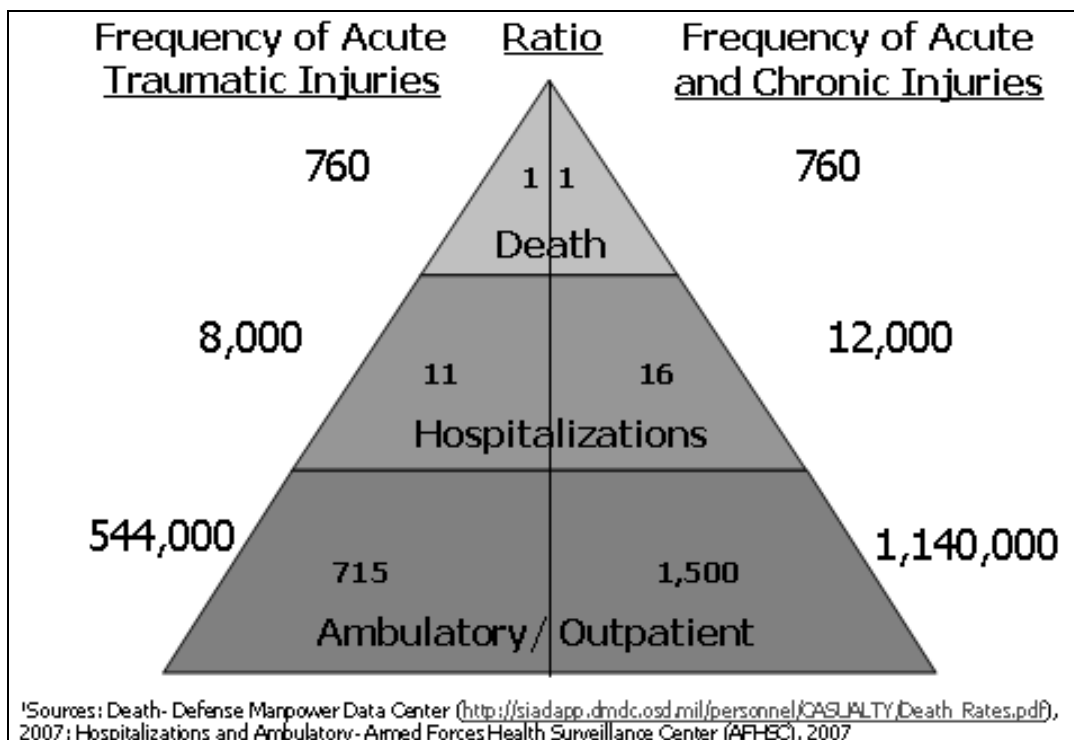


FIGURE 7-1-1. INJURY PYRAMID, ACTIVE DUTY MILITARY, 2006

(4) Injury-related musculoskeletal conditions (e.g., stress fractures, Achilles tendonitis, plantar fasciitis, bursitis) are an important piece of the problem, accounting for over 740,000 medical encounters in 2006 (628 visits per 1,000 person-years). Combined with traumatic injuries, the overall count is almost 2 million injury-related encounters per year. Eighty-two percent of injury-related musculoskeletal conditions were classified as inflammation/pain (overuse), followed by joint derangements (15 percent) and stress fractures (2 percent). The knee/lower leg (22 percent), lumbar spine (20 percent), and ankle/foot (13 percent) were leading body region categories.

(5) Auditory, visual, and oral-maxillofacial injuries are important, often overlooked military injury issues.

(a) Between 2003-2005, noise-induced hearing injury (NIHI) rates were, on average, 16.6 injuries per 1,000 person-years for females and 21.8 injuries per 1,000 person-years for males. Rates were highest for persons over 40 years of age (average rate, 2003-2005=53.7 per 1,000 person-years). Among occupational groups, general officers and executives had the highest NIHI rate over this time period (29.5 per 1,000 person-years), followed by enlisted personnel in training (14.3 per 1,000 person-years) and scientists and professionals (12.8 per 1,000 person-years). Deployment cycles and increased operational tempo between 2003-2005 have

significantly impacted NIHI prevalence. The emphasis on NIHI coding standards over the past few years seems to have resulted in better data quality, thus enhancing the ability to accurately monitor future NIHI rates.

(b) Eye injury rates were over 20 per 1,000 person-years for both males and females from 2002–2005. Rates were lowest among personnel under age 20 (average rate, 2002–2005=20.2 injuries per 1,000 person-years) and highest among personnel over age 40 (average rate, 2002–2005=23.9 injuries per 1,000 person-years). ‘Falls and miscellaneous’ and ‘guns/explosives’ were the leading causes of eye injury hospitalizations in 2005, while corneal abrasions were the leading type of eye injury.

(c) Oral-maxillofacial fracture rates were higher for Active Duty military males (1.2–1.5/1,000 person-years) than females (0.7–1.0/1,000 person-years) from 2000–2005. Oral-maxillofacial wound rates were similar among males and females from 2000–2005 (peak rate approximately 15/1,000 person-years, both males and females), with females having a slightly higher rate than males in 2000–2002. Personnel under age 25 had the highest rates of both oral-maxillofacial fractures and wounds and fighting was found to be the leading cause of oral-maxillofacial injury hospitalizations in 2005.

(6) Nonbattle injuries were the leading cause of air medical evacuations from Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF), from 2003–2006, for 35 percent and 37 percent of air evacuation cases, OIF and OEF, respectively. Distributions for NBI diagnosis ($p=0.32$) and injured body region ($p=0.51$) were similar for both operations. Leading causes of NBI were the same for both operations: sports/physical training (19–21 percent), falls/jumps (18 percent), motor vehicle-related accidents (12–16 percent), and crushing/blunt trauma (9 percent).

C. LESSONS LEARNED FROM SAFETY DATA ANALYSES (CHAPTER 4).

(1) Safety data provide detailed cause information needed for prevention planning. This cause information could serve as the basis for future improvements to external cause of injury coding of medical record data.

(2) Over a 10-year period (1993–2002), the leading activity associated with lost work day injuries among Air Force (AF) personnel was operation of vehicles and equipment. Sports and recreation activities accounted for four (that is, basketball, softball, flag football, and trail riding) of the top ten activities associated with lost work days.

(3) Lifting handling, and carrying (LHC) injuries were the third leading cause of lost work days and lost work day injuries among AF personnel. The LHC injuries were concentrated in the civilian AF population, age 35–55. The majority of injuries (74 percent) among both civilian and Active Duty affected the back and a large proportion (33 percent and 54 percent of lost work-day injuries, civilians and military, respectively) were associated with work on aircraft

components. Countermeasures to prevent LHC injuries in aircraft maintenance workers are warranted.

(4) Softball is the fifth leading cause of lost work day injuries among Active Duty AF personnel. Softball injuries are predominantly caused by three mechanisms: sliding, hit by ball, and collision. Potential prevention measures to reduce sliding-related injuries include use of breakaway bases, banning sliding, restricting headfirst sliding, and use of two home plates. Potential prevention measures to reduce hit-by-ball injuries include use of a helmet and face guard at all times, and use of reduced injury factor balls. Potential prevention measures to reduce collision-related injuries include training to call balls and use of two home plates. It appears that the widespread use of breakaway bases in the AF is at least correlated to a lower percentage of sliding injuries.

(5) Basketball is the second leading cause of lost work day injuries among Active Duty AF personnel. Two specific mechanisms—landing awkwardly and landing on someone else's foot—represent 43 percent of the injuries. The large number of ankle sprains presents a unique opportunity for prevention through the introduction of ankle braces.

(6) Flag football is the eighth leading cause of lost work day injuries among Active Duty AF personnel. Despite the fact that flag football is intended to provide a safer alternative to tackle football, 42 percent of injuries are due to contact. The high percentage of contact injuries represents an opportunity for prevention through rule changes and increased enforcement.

D. LESSONS LEARNED FROM SYSTEMATIC REVIEWS AND RESEARCH.

(1) We need to know what works to prevent injuries. Systematic reviews are an accepted method for identifying and evaluating the quality of existing interventions. When prevention strategies do not exist, intervention trials are needed to determine effectiveness and assess costs/savings.

(2) A systematic review of interventions to prevent physical-training related injuries revealed only six interventions with strong enough scientific evidence to be recommended by the Joint Services Physical Training Injury Prevention Work Group: (1) prevention of overtraining, (2) performance of multiaxial agility training, (3) use of mouth guards during high-risk activities, (4) use of semi-rigid ankle braces during high-risk activities, (5) consumption of nutrients to restore energy balance one hour following high intensity exercise, (6) use of synthetic blend socks to prevent blisters. Two interventions were not recommended due to evidence of ineffectiveness or harm: (1) use of back braces, harnesses, or support belts, and (2) use of anti-inflammatory medication prior to exercise. Twenty-three additional interventions could not be recommended because of lack of evidence, poor quality evidence, conflicting evidence, or evidence of harm.

(3) Evaluation of a parachute ankle brace (PAB) program demonstrated that the PAB protected against ankle injuries, especially ankle sprains, during military parachute training. Injuries to other parts of the lower body, exclusive of the ankle were not different among those who wore the brace and those who did not. Entanglement incidence was also similar among brace wearers and nonwearers, showing that the PAB did not complicate entanglements.

(4) A systematic review of scientific studies published between 1970–2006 on military motor vehicle (MMV) crashes revealed few studies on the topic. Nonetheless, the publications and unpublished data that were reviewed clearly indicated that MMV crashes are a problem. Given the overlap between operation of MMVs and privately owned vehicles (POVs), evaluation of interventions that have proven effective in POVs (such as, side airbags, electronic stability control, graduated driver licensing, primary seat belt laws, speed limit enforcement) is reasonable to consider.

(5) An intervention trial conducted in Army and AF basic training demonstrated that prescribing running shoes based on plantar shape did not reduce injury rates. The study showed there was little difference in injury rates among those who wore a standard stability shoe and those who wore a shoe designed by running shoe companies for a specific plantar shape.

7-2. RECOMMENDATIONS FOR MILITARY INJURY PREVENTION

- A. A systematic approach to the prevention of military injuries is needed.
- B. Begin with analysis of existing surveillance data. Identify the most common and/or serious injury types and/or causes on an annual or biannual basis.
- C. Next, identify ‘proven’, off-the-shelf strategies (strategies demonstrated to be effective) for the most common and/or serious injury types and/or causes.
- D. Set priorities for policy and program implementation on the basis of the magnitude of the problem (according to surveillance data) and preventability (as determined by reviews of proven prevention strategies).
- E. Implement programs and policies for top priorities.
- F. Evaluate implemented programs and policies to ensure effectiveness (injury reductions are obtained, benefits outweigh costs, and so forth). Some interventions will work as expected (such as, parachute ankle brace, standardized physical training), and some will not (such as, stretching prior to physical training, choosing running shoes according to foot type).

G. Where an understanding of risk factors and/or evaluation of prevention strategies is lacking for large (such as, falls, sports) or military-unique problems (such as, military vehicle accidents), initiate research.

